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Public Health Service • Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Environmental Health Service
Bureau of Radiological Health

Reports

A Priority System for the Inspection of X-Ray Facilities

Bobby L. Dillard and Charles M. Hardin[1]

A method of establishing a priority system for performing radiation safety inspections of specific x-ray facilities in Kentucky by a State radiation control program is described. Data obtained from past inspections of radiographic, fluoroscopic and dental x-ray facilities are evaluated, and a priority number is assigned to these facilities. Those facilities with the highest priority number will be surveyed first on the next round of inspections.

It is well established that x rays, particularly medical and dental x rays, contribute the largest unnecessary exposure to the population of any man-made source of ionizing radiation. It is the primary objective of any radiation control program to reduce this unnecessary exposure to the lowest practicable level without hindering the beneficial use of this invaluable tool.

Since the immediate impact of reducing radiation exposure to the population is not readily apparent as with other fields of public health, it is necessary to evaluate this impact by some other means. State radiological health programs are constantly faced with the problem of evaluating the effectiveness of their programs in improving the health of the population by their particular service.

Any method or system that a program uses to perform the evaluation of its effectiveness must consist of three distinct processes:

(1) A method of evaluation, based on the need for the specific service, must provide for establishing priorities, with the benefit of such service being the maximum for each dollar spent;

(2) The method should provide a mechanism to guide the program to reach its objective;

(3) The method must show that the activities performed by the program are based on the greatest need for the greatest number of people.

In the fall of 1968, the Kentucky Radiological Health Program initiated a system of establishing priorities for performing x-ray inspections throughout the state. This system provided the Kentucky Radiological Health Program with a method of evaluating the effectiveness of the program activities in accomplishing its objective of reducing x-ray exposure to the population. It is felt that the system used in Kentucky can be adopted, possibly with minor modifications, for radiation control programs of other States as well.

Priority system

Over the years, several methods have been used to establish the frequency of x-ray inspections. However, none of these methods seems to effectively combine deficiencies found during past in-

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spections with the number of people exposed, in a manner which would make it possible to determine the frequency of inspection required. Since the major objective of a radiation control program is to offer its service to the maximum number of people, the system which has been developed combines these two factors (deficiency of the x-ray machine and the number of people exposed by the x-ray machine) to establish a facility priority number.

In certain instances, there may be geographical, economical, occupational or other conditions that require special attention. Although the population affected may be small, the potential problem may be great. Under these circumstances, it may be necessary to deviate from, or even ignore, the priority number established.

The described system does not provide a priority number for medical therapeutic, industrial, or veterinarian x-ray facilities. The system specifically provides a priority number for medical, chiropractic, and dental x-ray facilities. In Kentucky, medical therapeutic, industrial, and veterinarian x-ray facilities represent less than 4 percent of the total registered x-ray facilities. In addition, their mode of operation differs so significantly from medical, chiropractic, and dental x-ray use that it is very difficult, if not impossible, to establish one system to cover all disciplines. With industrial and veterinarian x-ray facilities, only the operator is exposed—human patients not being a factor. With medical therapeutic x-ray facilities, the consideration for human patient exposure is entirely different than that for radiographic exposures. In the future, it is proposed to establish a priority system for these disciplines as well.

To arrive at the appropriate facility priority number, each machine in a given facility is handled individually. Tabulated in tables 1, 2 and 3 are debit points which are assigned to deficient items for radiographic, fluoroscopic and dental x-ray machines, respectively. These debit points were determined by relating the items with respect to their importance in reducing unnecessary radiation exposure. Both the operator and the patient were considered.

In the tables, each item is a positive question. The debit points given for each item are considered only if the machine does *not* have or use the item in question.

Table 1. Debit points for radiographic machines not meeting stated criteria

Criteria	Debit points
Operating personnel:	
Registered technician	3
Trained and experienced operators	6
Personnel monitoring system	3
Film and screen:	
Film speed (fast)	3
Type of intensifying screen (fast)	3
Darkroom:	
Adequate darkroom (clean, light-tight, etc.)	2
Automatic process or thermometer used	2
Timer used	2
Filtration and collimation:	
Proper filtration for kVp used	20
Rectangular variable aperture light-finding collimator	5
Adequate collimation	25
Timer:	
Deadman exposure switch	1
Adequate timer	3
Protective devices:	
Gonadal shield (primary)	3
Gonadal shield (secondary)	3
Adequate operator protection	5
Adequate primary and secondary barriers	6
Diagnostic type tube housing	5

The data obtained from past inspections are evaluated and assigned debit points obtained from the tables. It is important to emphasize again that the debit points are assigned only when the machine or facility does *not* meet criteria in question. If the machine meets the criteria, no points are assigned.

After the debit points are assigned, they are totaled. This total is then multiplied by the total

Table 2. Debit points for fluoroscopic machines not meeting stated criteria

Criteria	Debit points
Operating personnel:	
Radiologist	6
Personnel monitoring system	3
Equipment:	
Image intensifying device	4
Accessory shielding:	
Leaded gloves	2
Leaded apron	3
Bucky grid slot cover	1
Leaded drapes around screen	1
Dark adaptation:	
Adequate dark adaptation	3
Usual operating procedures:	
Amperage, <5 mA	4
Time, <5 minutes	4
Screen:	
Screen ganged to x-ray tube	5
Screen cannot rotate out of beam	4
Leaded glass satisfactory	2
Shutters function properly	1
Useful beam limited to screen	10
Distance:	
15 inches from target to panel	3
Roentgen output:	
Output <10 R/min at panel surface	5
< 5 R/min at panel surface	5
Filtration:	
Proper filtration for kVp used	10
Timer:	
Deadman exposure switch	1
Manually reset cumulative timer	2
Fluoroscopic room:	
Light-tight	1

Table 3. Debit points for dental machines not meeting stated criteria

Criteria	Debit points
Operating personnel:	
Trained and experienced operator	6
Personnel monitoring system	3
Film:	
Film speed (speed group, D or greater) (*f*)	7
Darkroom:	
Adequate darkroom (Clean, light-tight, etc.)	2
Thermometer used	2
Timer used	2
Pointer cone:	
Open end	2
Filtration and collimation:	
Proper filtrationf or kVp used	20
Adequate collimation	30
Timer:	
Adequate timer	3
Deadman exposure switch	1
Stability of tubehead:	
Tubehead stable	3
Protective devices:	
Diagnostic type tube housing	4
Adequate operator protection	6
Gonadal shield (secondary)	3
Adequate primary and secondary barriers	6

radiographic or dental exposures made per week for the machine in question. If the number of exposures has not been determined, but the number of patients exposed per week is known, the films per examination listed in table 4 may be used.

For fluoroscopic machines, an additional factor of 10 is used to compensate for the difference in the low number of milliampere-seconds used for radiographic examinations as opposed to the high number of milliampere-seconds used for fluoroscopic examinations.

The product obtained by the multiplication of the debit points and the exposures per week with the additional factor of 10 for fluoroscopic machines may be large and cumbersome; therefore, this product is divided by 100.

Radiographic and dental formula:

$$\text{Priority number} = \frac{\text{Total debit points} \times \text{exposures per week}}{100}$$

Fluoroscopic formula:

$$\text{Priority number} = \frac{\text{Total debit points} \times \text{examinations per week} \times 10}{100}$$

The priority number obtained above represents a number for a specific machine. If the facility has only one machine, this number also represents the facility priority number. When the facility has more than one machine, the priority numbers for all machines are added, and the total obtained is used as the facility priority number.

Table 4. Average workloads

Type of practice	Films per examination
Private practice radiologists	[a]3.0
Private practice	[a]1.8
Hospital	[a]2.6
Clinic	2.5
Mobile	1.4
Other	2.0
Dental	[a]4.2

[a] Obtained from reference 2.

Examples of using the system are as follows:

1. A dental office with one machine having a workload of 100 exposures per week was found to have the following deficient items:

Item	Debit points assigned
(a) No monitoring system	3
(b) No open end cone	2
(c) No gonadal apron	3
Total	8

In the formula:

$$\text{Priority number} = \frac{8 \times 100}{100} = 8.0$$

2. A clinic, physician's office or chiropractic office with one radiographic machine and with a workload of 20 exposures per week was found to have the following deficient items:

Item	Debit points assigned
(a) Operator not a registered technician	3
(b) Medium speed film used	3
(c) Circular cones used (rectangular variable aperture light finding collimator not used)	5
(d) No gonadal apron or protective cup	6
Total	17

In the formula:

$$\text{Priority number} = \frac{17 \times 20}{100} = 3.4$$

3. A private physician's office has a combination radiographic-fluoroscopic unit. The number of radiographic exposures per week is unknown, but 100 patients are radiographed per week. Five fluoroscopic examinations per week are performed. In addition, two spot radiographic films are made per fluoroscopic examination.

For the radiographic machine, the following deficiencies were found:

Item	Debit points assigned
(a) No monitoring system	3
(b) No thermometer	2
(c) Beam diameter—30 inches:	
No rectangular variable aperture light-finding collimator	5
No adequate collimation	25
	30
Total	35

Note: 100 patients × 1.8 films per examination (table 4) = 180 exposures per week.

In the formula:

$$\text{Priority number} = \frac{35 \times 180}{100} = 63.0$$

For the fluoroscopic machine, the following deficiencies were found:

Item	Debit points assigned
(a) No monitoring system	3
(b) No image intensifying device	4
(c) Milliamps used — 5 mA.	4
(d) Table top exposure rate—11 R/min	10
Total	21

In the formula:

$$\text{Priority number} = \frac{21 \times 5 \times 10}{100} = 10.5$$

For the fluoroscopic machine used as a radiograph during spot films, the following deficiencies were found:

Item	Debit points assigned
(a) No monitoring system	3
(b) No thermometer	2
Total	5

In the formula:

$$\text{Priority number} = \frac{5 \times 10}{100} = 0.5$$

For the facility priority number, the machine priority numbers are totaled.

Facility priority number = 63 + 10.5 + 0.5 = 74.0

Evaluation of system

Facilities with high priority numbers are grouped together. X-ray inspections are performed, giving preference to these particular high priority facilities. Since this system combines the deficient items with the number of people exposed, it is felt that this priority system serves as a method to assure that the greatest number of people receives the service the program offers and that the benefit of this service is at the maximum for each dollar spent.

In regard to evaluating the effectiveness of a radiation control program, the priority system can also serve as a useful "measuring stick". Figures 1 through 4 show graphically the distribution of facility priority numbers for dentists, physicians, hospitals and chiropractors, respectively. The data presented in these graphs were tabulated on x-ray inspections performed by the Kentucky Radiological Health Program from January 1967 to June 1969. Five hundred and seventy-nine facilities were evaluated, representing 25 percent of the total registered facilities in Kentucky.

Although these figures show that disciplines may fall into priority groups, the important point to observe is that there are some individual facilities which have very high priority numbers. Therefore, this system indicates that inspection frequencies cannot be established on disciplines as a group but must be evaluated on the merits of each specific facility.

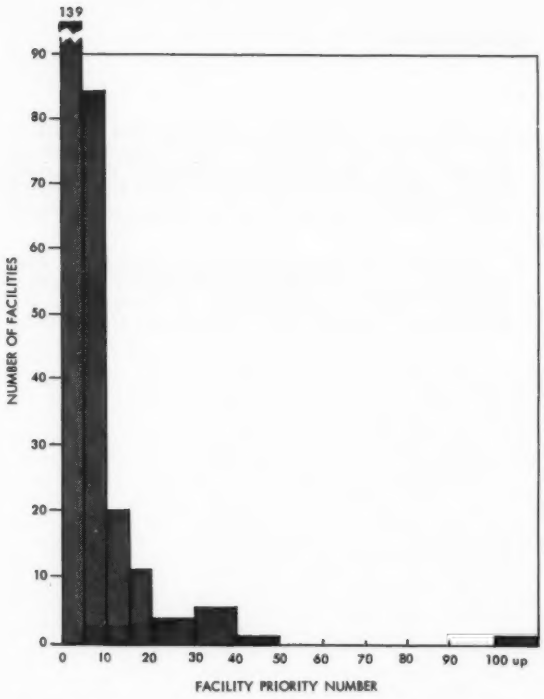

Figure 1. Distribution of priority numbers for dentists

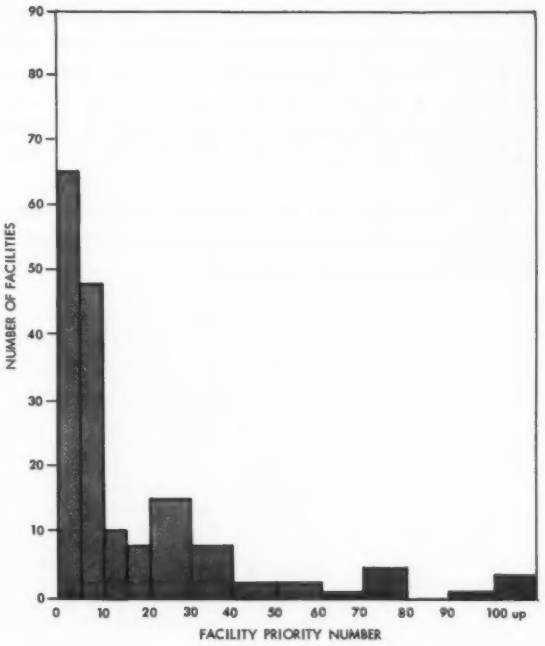

Figure 2. Distribution of priority numbers for physicians

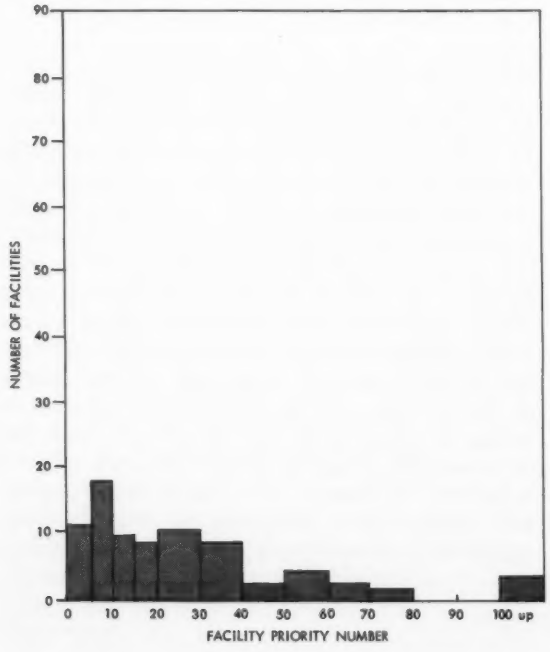

Figure 3. Distribution of priority numbers for hospitals

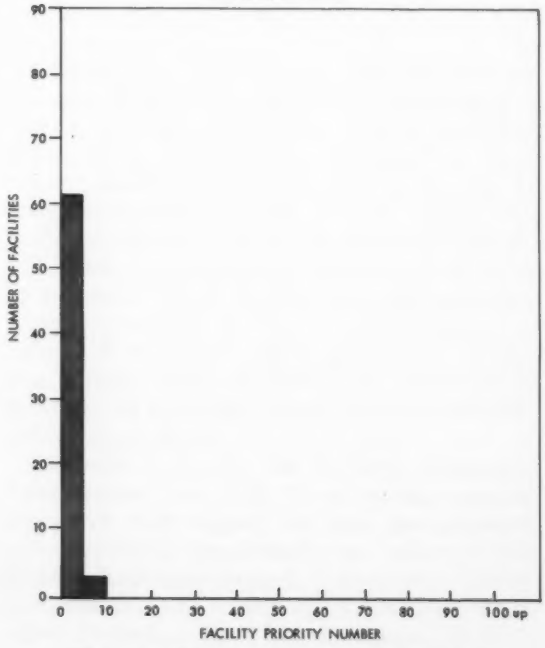

Figure 4. Distribution of priority numbers for chiropractors

The success and effectiveness of the program in meeting its objective can now be measured by a comparison of priority numbers from one year to the next. As the facility priority numbers decrease, a direct indication or measure of the reduction in unnecessary x-ray exposure to the population can be shown and quantitated numerically.

It is thus felt that the priority number system provides a method of evaluating the service offered by a radiation control program.

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(*1*) AMERICAN DENTAL ASSOCIATION COUNCIL ON DENTAL RESEARCH. Council adopts American standard speed classification for intraoral dental radiographic film: diagnostic grade. J Amer Dent 280–283 (April 1965).

(*2*) BUREAU OF RADIOLOGICAL HEALTH, PHS. Population exposure to X-rays, U.S., 1964, PHS Publication No. 1519. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1969

J. J. Mangeno and *M. E. Miles*[1]

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships totaled 0.05 curies in 1969 for all harbors. This is comparable to the average of 0.2 curies discharged per year during the preceding 3 years for all harbors and is less than the average of 4 curies reported discharged per year during the preceding 5 years. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U.S. Naval nuclear-powered ships. As of the end of 1969, there were 87 nuclear-powered submarines and four nuclear-powered surface ships in operation. In these shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system including heat exchangers which transfer the heat to water in a separate secondary steam system; the steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Discharges of radioactivity from ships occur primarily when reactor coolant water expands as a result of heating a reactor plant to operating temperature; this coolant passes through a purification system ion-exchange resin bed prior to discharge.

Construction, maintenance, overhaul and refueling of these nuclear propulsion plants involve various shipyards, submarine tenders, and submarine bases. Liquid wastes discharged at these support facilities result from operations such as draining shipboard reactor systems, decontaminating radioactivity contaminated piping systems, and laundering anti-contamination clothing worn by personnel. These facilities are equipped with processing systems to remove most of the radioactivity from liquid wastes prior to discharge into harbors. These facilities have continued to be improved to further reduce amounts of radioactivity discharged.

Discharge limits for the low-level radioactive liquid wastes from U.S. Naval nuclear-powered ships and their support facilities are consistent with applicable recommendations issued by the Federal Radiation Council, U.S. Atomic Energy Commission (AEC), National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP), and National Academy of Sci-

[1] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

Table 1. Radioactive liquid waste discharges to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1966 through 1969[a]

Facility	1966		1967		1968		1969	
	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies
Portsmouth, N.H; Naval Shipyard	155	0.01	265	0.01	171	0.01		[b] ND
Quincy, Mass[c]; Quincy Division		ND		ND		ND		ND
Groton–New London, Conn; Electric Boat Division, State Pier, and submarine base	1,274	.03	606	.01	469	.01	615	.01
Newport News, Va; Newport News Shipbuilding	1,581	.06	1,533	.04	1,146	.03	870	.02
Norfolk, Va; Naval Shipyard and base	1,051	.03	1,784	.03		ND		ND
Charleston, S.C; Naval Shipyard and base	369	.04	320	.01		ND		ND
Pascagoula, Miss; Ingalls Shipbuilding Division		ND		ND		ND		ND
San Diego, Calif; Navy Pier at Ballast Point		ND		ND		ND		ND
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	270	.19		ND	391	.03		ND
Bremerton, Wash; Puget Sound Naval Shipyard		ND		ND		ND		ND
Pearl Harbor, Hawaii Naval Shipyard and base	654	.03	683	.01	886	.01	1,279	.01
Apra Harbor, Guam		ND		ND		ND		ND
All other harbors	178	.01		ND		ND		ND
Totals[d]	5,532	0.40	5,191	0.11	3,063	0.10	2,764	0.05

[a] Radioactivity data are recorded as if the entire radioactivity consisted of cobalt–60. Volumes are reported prior to dilution.
[b] Where discharges for a year totaled less than 0.005 curies, ND is reported.
[c] General Dynamics, Quincy Division, discharged a total of 0.02 curies into the river at Quincy, Mass., from 1961 through March 1969 when all work on U.S. Naval nuclear-powered ships was completed.
[d] Total curies for each year include discharges reported as ND.

ences—National Research Council (*1–5*). In consonance with these recommendations, the policy of the U.S. Navy is to minimize the amounts of radioactivity discharged into harbors. To implement this policy, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces. The predominant long-lived radionuclide (i.e., half-life greater than one day) in these corrosion and wear products is cobalt–60, which has a 5.3 year half-life; cobalt–60 also has the lowest concentration guide for water (*2–4*) for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is controlled by assuming that all the long-lived radioactivity is cobalt–60. Short-lived radionuclides decay rapidly and are therefore less limiting than long-lived radioactivity for waste disposal considerations.

Fission products produced in the reactor are retained by being metallurgically bound within the fuel alloy. The fission gases, krypton and xenon, are also retained within the fuel elements. As a result, the total radioactivity attributed to long-lived fission products (strontium–90 and cesium–137) in discharges from U.S. Naval nuclear-powered ships and their support facilities has been less than one millicurie per year for all harbors combined.

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.01 percent of deuterium normally present in water, and other nuclear reactions. Although tritium has a 12-year half-life, the radiation produced is of such low energy that the radioactivity concentration limit used for tritium is 100 times that for cobalt–60. This tritium is in the oxide form and therefore completely soluble in water; it does not concentrate in marine life or collect on sediment since it is chemically indistinguishable from water. The small amounts of tritium from Naval reactors are rapidly diluted to the concentrations already existing in the environment. Since tritium from Naval reactors is not significant for waste disposal considerations in harbors, it is not included with other long-lived radionuclides in this report.

The total amounts of long-lived radioactivity discharged into various harbors during the past four years are listed in table 1, which updates information in references 6, 7, 8, and 9; included are data from U.S. Naval nuclear-powered ships and from supporting shipyards, tenders, and submarine bases. Locations listed in table 1 include operating bases and home ports in the United States and possessions which have been regularly visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this

table are reported as if the entire radioactivity consisted of cobalt–60, the predominant long-lived radionuclide.

The table shows that nearly all the radioactive discharges occur where shipyards are overhauling nuclear-powered ships. In 1969, for example, a total of 0.05 curies was discharged into all harbors, including those outside the United States. Essentially all of this came from shipyards overhauling nuclear-powered ships. Less than one percent of the total was discharged into all other harbors entered by U.S. Naval nuclear-powered ships in 1969. The low amounts of radioactivity in table 1 discharged by each facility are comparable to amounts discharged into rivers by a number of other facilities in the United States involved in nuclear power programs where stringent waste disposal controls similar to those used by the Navy are enforced.

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper and scrap materials are collected by nuclear-powered ships and their support facilities. Disposal of these wastes at sea is prohibited by the U.S. Navy. Solid materials from ships are transferred to a shipyard or other support facilities for packaging and disposal. In a similar fashion, shipyards and other support facilities also package for disposal solid waste, such as filters and ion-exchange resin resulting from liquid waste processing operations. For ultimate disposal, solid radioactive wastes are shipped to AEC-approved burial sites since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. Table 2 summarizes total radioactivity and volumes of radioactive wastes disposed of from 1966 through 1969.

Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1966 through 1969[a]

Facility	1966		1967		1968		1969	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies
Portsmouth, N.H; Naval Shipyard	194	9.5	300	198.1	314	150.7	77	3.1
Quincy, Mass; Electric Boat Division		[b] ND		ND		ND		ND
Groton, New London, Conn; Electric Boat Div. tender at State Pier, and submarine base	148	1,092.8	46	17.0	44	20.7	83	327.6
Newport News, Va; Newport News Shipbuilding	70	8.9	167	701.9	144	10.2	170	382.3
Norfolk, Va; Naval Shipyard and tender	43	2.5	108	85.6	23	11.2	63	8.4
Charleston, S.C; Naval Shipyard and tender	77	5.6	151	52.0	136	109.9	149	9.1
Pascagoula, Miss; Ingalls Shipbuilding Division		ND		ND		ND		ND
San Diego, Calif; tenders at Ballast Point	6	.1	7	.2	14	7.6	4	2.1
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	90	367.0	92	22.8	76	6.6	78	4.8
Bremerton, Wash; Puget Sound Naval Shipyard	14	.5	141	192.8	139	48.2	106	41.6
Pearl Harbor, Hawaii; Naval Shipyard and base	7	.3	11	1.0	32	5.5	41	3.3
Total	649	1,487.2	1,023	1,271.4	922	370.6	771	782.3

[a] Where total radioactivity is less than 0.5 curies, ND is reported in this table.
[b] This table includes waste from tenders and nuclear-powered ships since all such waste is transferred to the above support facilities.

Environmental monitoring

Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. These surveys are performed to verify the adequacy of liquid waste disposal procedures and limits.

Shipyards, tenders, and submarine bases have taken periodic samples of harbor water and bottom sediment in the vicinity of berths used by nuclear-powered ships, beginning in each harbor prior to operation of these ships. Radioactivity data from harbor water and sediment samples taken by individual facilities indicate that operation and maintenance of nuclear-powered ships have not caused significant changes in the gross radioactivity of harbor water or sediment. However, relatively large variations in gross radioactivity measured in environmental samples do occur from changes in natural and fallout sources. Because of these variations, monitoring for gross radioactivity in harbor water and sediment is not sufficient to detect small changes in environ-

Table 3. Summary of 1969 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built

Facility	Number of samples with concentration[a] of cobalt-60:			Total bottom area with cobalt-60 over 10 pCi/cm² (km²)	Estimated total cobalt-60 in top layer of sediment[b] (Ci)
	<10 pCi/cm²[a]	10–100 pCi/cm²[a]	>100 pCi/cm²[a]		
Portsmouth, N.H. Naval Shipyard	176	0	0	0	ND
Quincy, Mass; Quincy Division (final survey)	24	0	0	0	ND
Groton–New London, Conn; Electric Boat Division, State Pier, and submarine base	322	130	2	0.1	0.02
Newport News, Va; Newport News Shipbuilding	151	1	0	.001	ND
Norfolk, Va; Naval Shipyard and base	344	0	0	0	ND
Charleston, S.C; Naval Shipyard and base	378	1	0	.001	ND
Pascagoula, Miss; Ingalls Shipbuilding Division	174	0	0	0	ND
San Diego, Calif; Navy Pier at Ballast Point	159	1	0	.001	ND
Long Beach, Calif; Naval Shipyard and base	160	0	0	0	ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	444	0	0	0	ND
Bremerton, Wash; Puget Sound Naval Shipyard	138	0	0	0	ND
Pearl Harbor, Hawaii Naval Shipyard and base	281	7	0	.05	ND
Apra Harbor, Guam	123	0	1	0	ND

[a] Minimum detectable radioactivity is approximately 2 pCi/cm². Results in units of pCi/gram are approximately half the value in pCi/cm².
[b] Total is from areas with cobalt-60 over 10 pCi/cm², which were in immediate vicinity of piers used for berthing nuclear-powered ships. Where total cobalt-60 is less than 0.01 curie, ND is reported. Core samples more than 1 foot deep from several harbors show that total cobalt-60 present may be two to five times that measured in the surface layer.

mental radioactivity which might be attributed to operation and maintenance of naval nuclear-powered ships.

To monitor for these small changes in environmental radioactivity, water and sediment samples are analyzed specifically for cobalt–60. This radionuclide is a sensitive tracer to follow environmental distribution of radioactivity because it has the longest half-life and is the predominant long-lived radionuclide in liquid waste discharges; in addition, cobalt–60 concentrations from fallout are less than the minimum detectable with the sensitive monitoring equipment available at support facilities.

Once each quarter year a total of at least five water samples is taken at various locations in each harbor in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross radioactivity and for cobalt–60, using a sodium iodide scintillation detector with a multichannel analyzer. No increases in gross radioactivity of harbor water have been detected. No harbor water samples have shown detectable cobalt–60 radioactivity; the minimum level detectable with the equipment and procedures used is 100 pCi/liter. The concentration of cobalt–60 in this water would have to be 300 times greater than 100 pCi/liter to reach maximum levels permitted by agencies such as the U.S. Atomic Energy Commission and International Commission on Radiological Protection.

Monitoring for cobalt–60 in harbor bottom sediment is conducted each quarter year by collecting 20 to 100 samples with a 6-inch-square sampler. Equipment and procedures for analyzing sediment samples are the same as for water samples discussed above. Samples are taken of the top 1/2 to 1 inch of sediment in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. Results of the 1969 surveys, which involved a total of 3,637 samples, are summarized in table 3. Low-level cobalt–60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt–60 is not detectable above background levels in general harbor bottom areas away from these piers.

Samples from each of these harbors are also checked at least annually by an AEC laboratory to ensure analytical procedures are correct and standardized. In addition, the U.S. Navy cooperates in U.S. Public Health Service (PHS) surveys in some U.S. harbors. Results reported in table 3 are consistent with these AEC and PHS checks.

Twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were 0.01 to 0.04 millirem per hour, the same as background radiation levels in

similar areas. Thus there is no evidence in these ports that radioactivity from sediment is washing ashore.

Throughout the year, film badges are posted at locations outside the boundaries of areas where work with radioactivity is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

All exhaust stacks at support facilities which could have discharged airborne radioactivity were monitored. There were no discharges of airborne radioactivity to the atmosphere measured above concentrations normally present in the atmosphere.

In addition to the locations listed in table 3, environmental monitoring has been accomplished by U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Results of the surveys in the harbor at Rota, Spain, have not shown detectable cobalt–60 in harbor sediment samples. In 1965, in Holy Loch, more cobalt–60 radioactivity than expected was detected in harbor bottom sediment and on shore line mud flat areas uncovered at low tide. However, there had been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results confirmed that radiation levels in the vicinity of the Holy Loch anchorage were far below those which were at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public. Environmental monitoring during 1969 showed radioactivity levels in Holy Loch are steadily declining.

Summary

Overall results of environmental surveys performed in 1969 indicate the following:

(1) No increase of radioactivity above normal background levels has been detected in harbor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

(2) Discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment.

(3) Low-level cobalt–60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt–60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than one curie of cobalt–60.

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Standby Milk Surveillance Network

Thomas J. Sharpe and *John L. Stein*[1]

The operation of the Standby Milk Surveillance Network of the Southwestern Radiological Health Laboratory is described. Portions of the network have been activated on several occasions. Fresh fission products have been defined in a number of samples collected from processing plants in the network, although in all cases the concentrations of the radionuclides present have been well below the recommendations of the Federal Radiation Council.

Since 1954, the Public Health Service (PHS), under terms of A Memorandum of Understanding, SF54-373, negotiated between the PHS and the Atomic Energy Commission (AEC), has been charged with the responsibility of providing a radiological safety program beyond the boundaries of the AEC's Nevada Test Site (NTS). Prior to this time, a combination of military and AEC laboratory personnel had provided radiological safety services for the test series conducted. An offsite Radiological Safety Organization (which later evolved into the Southwestern Radiological Health Laboratory (SWRHL), was established in Las Vegas, Nev., to direct and coordinate the various activities of radiation monitoring and environmental surveillance needed to implement the program. In addition to monitoring radioactivity released by individual nuclear tests, SWRHL operates a number of surveillance networks for the AEC on a continuous basis to document any increase in radiation levels due to nuclear testing programs. These networks sample milk, water, and air in the offsite areas and provide more specific information regarding changes in the radiological situation than does radiation monitoring.

Purpose and scope

The value of milk as a sensitive indicator of atmospheric radiocontaminant intake by the general population has been well documented. Extensive reliance on milk sampling for information on current levels and long-range trends of specific contaminants is based upon several facts. Milk is one of the most universally consumed foodstuffs. It reflects several important nuclides (strontium–90, iodine–131, cesium–137) deposited in the area from which it is collected, and it is one of the most convenient dietary constituents to collect, handle, and analyze.

Prior to the establishment of the Standby Milk Surveillance Network (SMSN), other milk sampling networks had been set up by SWRHL and by Headquarters, Bureau of Radiological Health (BRH). The Routine Milk Surveillance Network (RMSN) was set up by SWRHL in 1959 to provide concentrated surveillance in an area limited to within 300 miles of NTS. The Pasteurized Milk Network (PMN), operated by BRH, covers the entire United States and has the objective of providing data on current radionuclide concentrations and long-term trends. Prior to the creation of the SMSN, it was recognized that occasions might arise when concentrated surveillance of milksheds would be needed in areas outside those covered by the RMSN. It was also recognized the limited number of stations in the PMN could not properly reflect the intrusion of radioactive contaminants into all the milksheds possibly affected by a release of radioactivity from a nuclear device or reactor test at NTS. Therefore, the SMSN was created in 1964 to provide ad-

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Figure 1. Standby milk surveillance stations

ditional surveillance capability. This new network differed from those established previously in that it was not designed to operate on a continuous basis. It was decided that the SMSN could be activated after a release had occurred and the direction in which the radioactive material was moving had been defined, thereby keeping the number of samples to a minimum without limiting the effectiveness of the network.

Organization

Originally, the network consisted of 161 milk processing plants in the eleven western-most States. The State of Texas was also included to the extent that either samples or analytical results from this State's milk sampling network would be made available to SWRHL upon request. In 1969, the remainder of the States west of the Mississippi River were added to the network, bringing the total number of milk processing plants in the network to 201. The current network is shown in figure 1.

The network stations were established through the cooperation and participation of personnel from the Bureau of Radiological Health, Environmental Health Service, and the Bureau of Food and Pesticides, Food and Drug Administration, (formerly, Division of Radiological Health and Division of Environmental Engineering and Food Protection), and State and local milk control agencies.

The milk processing plants in the network were selected to provide a geographical distribution such that any contamination detected could be traced to a specific milkshed. The management of each selected processing plant was then asked to participate in the program by supplying samples for radionuclide analysis and providing basic information for evaluation and reporting purposes.

Network activation

To activate any part of the network, the project officer at SWRHL contacts the appropriate PHS regional office. This office is then responsible for contacting the State milk control officials concerned; they, in turn, notify local milk control personnel (city or county) who begin collecting and airmailing samples to SWRHL for analysis. The regional offices notify the Chief, Milk Sanitation Section, Food and Drug Administration, and SWRHL notifies the Chief, Radiological Surveillance Branch, Bureau of Radiological Health, once the activation procedure has begun.

Except for periodic 1-day trial runs to determine the readiness of the network, sampling at the stations activated is normally carried on for a 1-week period. This may be extended when deemed necessary. All agencies involved in the sample collection effort have been instructed to provide raw milk samples. This policy has been instituted for several reasons. For example, some processors receive raw milk from numerous, widely-scattered milksheds. Sampling of the pasteurized milk could possibly mask significant amounts of contaminants in the milk coming from a portion of the milksheds supplying a particular plant. The time between milking and analysis is also reduced by sampling raw milk. This factor is important since the majority of the radionuclides which may be injected into the environment by nuclear testing possess half-lives in terms of hours and days.

Sample analysis and reporting

Upon receipt, samples are analyzed by gamma spectroscopy for iodine–131, cesium–137, barium–140, and other radionuclides. The first sample received from each station and all subsequent

Table 1. Summary of operation of the Standby Milk Surveillance Network[a]

Nuclear event	State notified	Date of activation	Stations activated	Stations positive for iodine–131	Samples collected	Samples positive for iodine–131
Kiwi–TNT[b]	California	1/12/65	8	0	55	0
Palanquin[c]	Idaho	4/16/65	11	3	175	29
	Montana	4/17/65	13	7	175	15
	Oregon	4/16/65	5	1	28	1
	Utah	4/17/65	5	0	32	0
	Washington	4/17/65	10	0	54	0
	Wyoming	4/17/65	6	0	37	0
Pin Striped[d]	California	4/25/66	7	0	27	0
	Colorado	4/25/66	13	0	64	0
	Idaho	4/25/66	11	1	49	2
	Utah	4/25/66	9	1	45	2
	Wyoming	4/25/66	6	0	41	0
NRX–A5[b]	Utah	6/29/66	4	0	17	0
Phoebus 1B EP–4[b]	California	2/23/67	5	0	34	0
	Idaho	2/23/67	11	1	70	1
	Montana	2/23/67	5	0	35	0
	Utah	2/23/67	8	1	49	1
	Wyoming	2/23/67	5	0	23	0
Non U.S. test	California	6/22/67	8	0	46	0
Umber[d]	California	6/29/67	11	0	57	0
NRX–A6[b]	California	12/18/67	11	0	49	0
Hupmobile[d]	California	1/19/68	5	0	25	0
Cabriolet[c]	Idaho	1/28/68	9	0	49	0
	Montana	1/28/68	7	0	41	0
Buggy I[c]	Idaho	3/12/68	6	0	32	0
	Montana	3/12/68	4	0	30	0
	Utah	3/12/68	3	0	18	0
	Wyoming	3/12/68	3	0	13	0
Schooner[c]	Colorado	12/10/68	11	0	60	0
	Idaho	12/10/68	7	0	34	0
	Montana	12/10/68	6	0	19	0
	Utah	12/10/68	8	0	45	0
	Wyoming	12/10/68	6	0	23	0

[a] The network was not activated in 1969.
[b] Nuclear reactor experiment.
[c] Plowshare experiment.
[d] Weapon test.

samples found to contain fresh fission products receive radiochemical analysis for strontium–89 and strontium–90. If the iodine–131 concentration in any sample should exceed 100 pCi/liter, regional FDA milk and food consultants would be contacted. These personnel would then notify State public health authorities in their region and alert them to the increased levels of iodine–131.

Analytical results of all samples are reviewed, evaluated, and tabulated by SWRHL. The data are then sent to the PHS regional milk consultants concerned for distribution to the state authorities in their region.

Operational experience

Portions of the network have been activated on several occasions. Fresh fission products have been detected in a number of samples collected from processing plants in the network, although in all cases, the concentrations of the radionuclides present have been well below the standards prescribed by the Federal Radiation Council (*1*). A summary of the operation of the Standby Milk Surveillance Network is presented in table 1.

Summary

The practicality of the "standby" concept of milk surveillance has been proven through the operation of the SMSN. Experience has shown that after initial notification samples can be received and counted in as little as 1 day's time, although 2 to 3 days are usually required. By maintaining communication with local control authorities and by staging periodic trial runs, an excellent degree of readiness has been maintained in the system.

REFERENCE

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, April 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radioactive contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements, calcium and potassium, which are found in milk have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of

Figure 1. Milk sampling networks in the Western Hemisphere

both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131, cesium–137 and barium–140. Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 14 participated in the experiment.

The iodine–13 ·nd cesium–137 results show much improvement over previous tests. Barium–140 results also look good which is encouraging, since this is the first time barium–140 was analyzed for this type of experiment. However, strontium–89 and strontium–90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pas-

teurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine–131, Cesium–137, Barium–140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine–131, cesium–137, and barium–140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data, one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a one or two year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which, if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

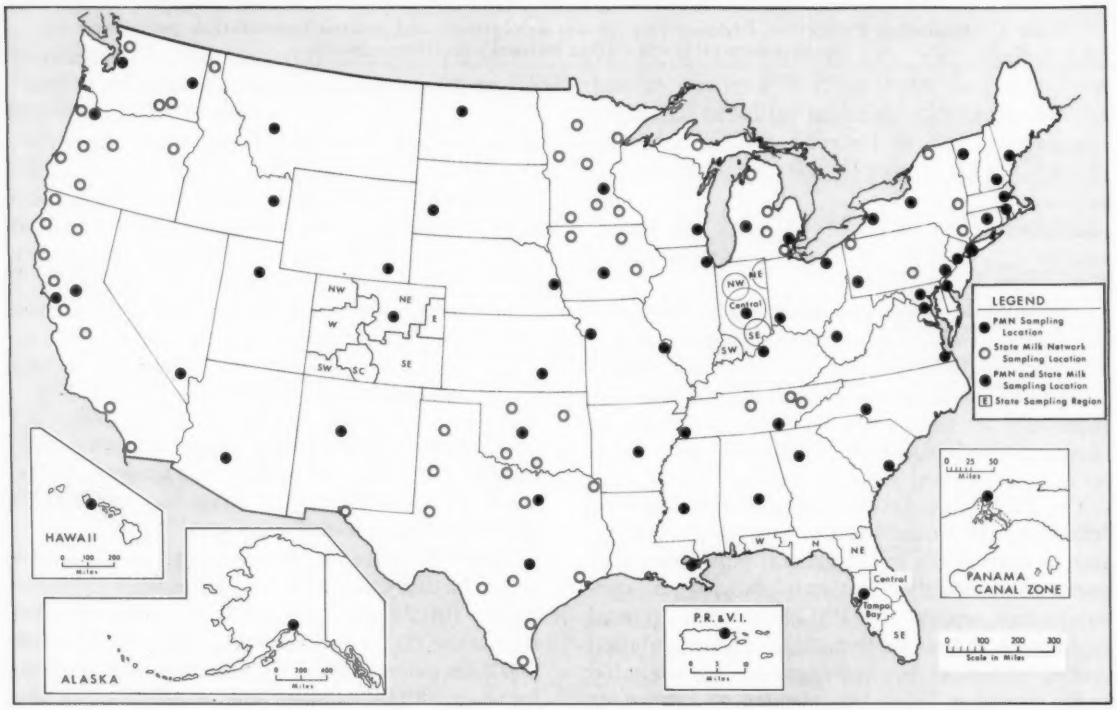

Figure 2. State and PMN milk sampling locations in the United States

to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131 and cesium–137 for April 1970 and the 12-month period, May 1969 to April 1970. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–140 data have been omitted from table 3 since levels at the great majority of the stations for April 1970 were below

Table 3. Concentrations of radionuclides in milk for April 1970 and 12-month period May 1969 through April 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	5	6	0 (5)	0	11 (5)	10
Alaska:	Palmer[c]	P	5	5	0 (4)	0	3 (4)	4
Ariz:	Phoenix[c]	P	2	1	0 (5)	0	0 (5)	0
Ark:	Little Rock[c]	P	9	14	0 (4)	0	19 (4)	18
Calif:	Sacramento[c]	P	5	2	0 (4)	0	0 (4)	0
	San Francisco[c]	P	6	2	0 (5)	0	0 (5)	0
	Del Norte	P	23	20	0	0	15	19
	Fresno	P	2	2	0	0	0	7
	Humboldt	P	7	5	0	0	0	6
	Los Angeles	P	2	2	0	0	0	3
	Mendocino	P	4	3	0	0	0	4
	Sacramento	P	3	3	0	0	0	4
	San Diego	P	2	2	0	0	0	2
	Santa Clara	P	2	2	0	0	0	4
	Shasta	P	3	3	0	0	0	5
	Sonoma	P	6	3	0	0	0	5
Colo:	Denver[c]	P	4	5	0 (5)	0	3 (5)	2
	West	P	(d)		(*) (6)	(*)	(*) (6)	(*)
	Northeast	R	(d)		(*) (2)	(*)	(*) (2)	(*)
	East	R	(d)		(*)	(*)	(*)	(*)
	Southeast	R	(d)		(*)	(*)	(*)	(*)
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		(*) (2)	(*)	(*) (2)	(*)
	Northwest	R	(d)		(*)	(*)	(*)	(*)
Conn:	Hartford[c]	P	7	8	0 (4)	0	5 (4)	10
	Central	P	7	7	0 (4)	0	8 (4)	11
Del:	Wilmington[c]	P	7	8	0 (5)	0	6 (5)	5
D.C:	Washington[c]	P	8	7	0 (3)	0	3 (3)	5
Fla:	Tampa[c]	P	5	6	0 (4)	0	46 (5)	54
	West	R	7	11	0	0	11	21
	North	R	7	11	0	0	25	25
	Northeast	R	6	7	0	0	37	52
	Central	R	NA	8	0	0	40	43
	Tampa Bay area	R	6	7	0	0	46	54
	Southeast	R	8	8	0	0	39	79
Ga:	Atlanta[c]	P	12	9	0 (4)	0	18 (4)	18
Hawaii:	Honolulu[c]	P	0	2	0 (4)	0	0 (4)	0
Idaho:	Idaho Falls[c]	P	5	5	0 (4)	0	0 (4)	3
Ill:	Chicago[c]	P	6	7	0 (4)	0	5 (4)	8
Ind:	Indianapolis[c]	P	7	8	0 (4)	0	3 (4)	5
	Northeast	P	7	10	0	0	10	12
	Southeast	P	8	10	0	0	10	12
	Central	P	7	9	0	0	10	10
	Southwest	P	8	10	0	0	0	12
	Northwest	P	7	10	0	0	10	17
Iowa:	Des Moines[c]	P	7	6	0 (5)	0	0 (5)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	8	8	0 (4)	0	0 (4)	0
Ky:	Louisville[c]	P	8	8	0 (4)	0	3 (4)	4
La:	New Orleans[c]	P	16	15	0 (4)	0	22 (4)	18
Maine:	Portland[c]	P	9	11	0 (5)	0	15 (5)	22
Md:	Baltimore[c]	P	5	8	0 (4)	0	3 (4)	6
Mass:	Boston[c]	P	8	10	0 (4)	0	18 (4)	20
Mich:	Detroit[c]	P	9	8	0 (5)	0	3 (4)	8
	Grand Rapids[c]	P	9	9	0 (4)	0	9 (4)	11
	Bay City	P	7	7	(*) (2)	(*)	19 (2)	9
	Charlevoix	P	NA	11	(*) (4)	(*)	15 (4)	18
	Detroit	P	5	6	(*) (4)	(*)	3 (4)	6
	Grand Rapids	P	9	8	(*) (4)	(*)	6 (4)	11
	Lansing	P	11	8	(*) (2)	(*)	13 (2)	15
	Marquette	P	NA	11	(*) (2)	(*)	23 (2)	25
	Monroe	P	NA	6	(*) (2)	(*)	0 (2)	2
	South Haven	P	NA	NA	(*) (4)	(*)	3 (4)	9
Minn:	Minneapolis[c]	P	8	10	0 (4)	0	2 (4)	6
	Bemidji	P	13	16	0	0	22	25
	Mankato	P	4	7	0	0	0	11
	Rochester	P	7	8	0	0	13	9
	Duluth	P	13	17	0	0	19	20
	Worthington	P	6	7	0	0	0	0
	Minneapolis	P	9	11	0	0	14	13
	Fergus Falls	P	6	9	0	0	0	0
	Little Falls	P	7	9	0	0	13	12
Miss:	Jackson[c]	P	13	12	0 (2)	0	8 (2)	12
Mo:	Kansas City[c]	P	9	8	0 (4)	0	0 (4)	1
	St. Louis[c]	P	6	8	0 (5)	0	3 (5)	2
Mont:	Helena[c]	P	4	5	0 (3)	0	5 (3)	5
Nebr:	Omaha[c]	P	4	6	0 (4)	0	0 (4)	1
Nev:	Las Vegas[c]	P	2	1	0 (4)	0	0 (4)	0

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for April 1970 and 12-month period May 1969 through April 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H:	Manchester[c]	P	6	8	0 (4)	0	5 (4)	17
N.J:	Trenton[c]	P	0	8	0 (4)	0	2 (4)	6
N.Mex:	Albuquerque[c]	P	4	3	0 (4)	0	0 (4)	0
N.Y:	Buffalo[c]	P	5	7	0 (4)	0	5 (4)	7
	New York City[c]	P	9	10	0 (4)	0	14 (4)	12
	Syracuse[c]	P	6	7	0 (4)	0	5 (4)	9
	Albany	P	4	4	0 (4)	0	0 (4)	0
	Buffalo	P	NS	(c)	NS	0	NS	0
	Massena	P	(c) (2)	6	0 (2)	0	24 (2)	0
	Newburg	P	(c) (3)	5	0 (4)	0	0 (4)	0
	New York City	P	5 (3)	7	0 (4)	0	0 (4)	0
	Syracuse	P	(c)	3	0 (2)	0	0 (2)	0
N.C.:	Charlotte[c]	P	12	12	0 (2)	0	11 (2)	13
N.Dak:	Minot[c]	P	10	10	0 (4)	0	16 (4)	14
Ohio:	Cincinnati[c]	P	6	8	0 (5)	0	4 (5)	3
	Cleveland[c]	P	8	9	0 (4)	0	3 (4)	5
Oklahoma:	Oklahoma City[c]	P	7	7	0 (4)	0	5 (4)	8
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	6	6	0 (4)	0	9 (4)	6
	Baker	P	NA	3	(c)	(c)	(c)	(c)
	Coos Bay	P	NA	6	(c)	(c)	(c)	(c)
	Eugene	P	NA	3	(c)	(c)	(c)	(c)
	Medford	P	NA	2	(c)	(c)	(c)	(c)
	Portland composite	P	NA	4	(c) (4)	(c)	(c) (4)	(c)
	Portland local	P	NA	5	(c) (4)	(c)	(c) (4)	(c)
	Redmond	P	NA	2	(c)	(c)	(c)	(c)
	Tillamook	R	NA	7	(c)	(c)	23	16
Pa:	Philadelphia[c]	P	8	9	0 (4)	0	3 (4)	4
	Pittsburgh[c]	P	9	11	0 (4)	0	2 (4)	7
	Dauphin	P	6	7	0	2	0	12
	Erie	P	9	11	0	6	17	23
	Philadelphia	P	9	8	0	4	15	11
	Pittsburgh	P	13	11	0	3	0	12
R.I.:	Providence[c]	P	8	9	0 (5)	0	10 (5)	14
S.C.:	Charleston[c]	P	10	10	0 (3)	0	20 (3)	22
S.Dak:	Rapid City[c]	P	4	8	0 (4)	0	0 (4)	4
Tenn:	Chattanooga[c]	P	10	10	0 (3)	0	11 (3)	12
	Memphis[c]	P	8	9	0 (5)	0	3 (5)	4
	Chattanooga	P	11	12	0 (4)	0	11 (4)	13
	Clinton	P	13	16	0	1	11	11
	Knoxville	P	7	10	0 (2)	0	11 (2)	6
	Nashville	P	6	8	0 (2)	0	12 (2)	7
	Fayetteville	P	12	10	0	0	10	16
Tex:	Austin[c]	P	5	2	0 (4)	0	3 (4)	4
	Dallas[c]	P	9	6	0 (2)	0	11 (2)	7
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R'	NS	5	NS	0	NS	2
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	6	4	0	0	0	2
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	6	7	0	0	0	10
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	3	2	0	0	0	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	8	10	0	0	0	8
	Tyler	R	20	17	0	0	10	12
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	7	NS	0	NS	8
Utah:	Salt Lake City[c]	P	3	4	0 (4)	0	0 (4)	2
Vt:	Burlington[c]	P	7	8	0 (5)	0	10 (5)	12
Va:	Norfolk[c]	P	7	10	0 (4)	0	6 (4)	7
Wash:	Seattle[c]	P	6	6	0 (5)	0	0 (5)	8
	Spokane[c]	P	6	6	0 (4)	0	0 (4)	3
	Benton County	R	NS	1	NS	0	NS	7
	Franklin County	R	3	2	0	0	10	3
	Sandpoint, Idaho	R	9	11	0	0	14	26
	Skagit County	R	6	7	0	0	15	14
W.Va:	Charleston[c]	P	7	9	0 (5)	0	8 (5)	5
Wisc:	Milwaukee[c]	P	6	7	0 (4)	0	11 (4)	10
Wyo:	Laramie[c]	P	7	6	0 (5)	0	0 (5)	2
CANADA								
Alberta:	Calgary	P	8	8	(d)		9	17
	Edmonton	P	6	7	(d)		13	16
British Columbia:	Vancouver	P	11	10	(d)		19	30
Manitoba:	Winnipeg	P	7	8	(d)		20	24

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for April 1970 and 12-month period May 1969 through April 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
New Brunswick:	Fredericton	P	12	13	[d]		16	19
Newfoundland:	St. Johns	P	9	10	[d]		15	20
Nova Scotia:	Halifax	P	13	14	[d]		26	29
Ontario:	Ft. William	P	8	8	[d]		9	13
	Ottawa	P	16	14	[d]		30	29
	Saulte Ste. Marie	P	4	5	[d]		12	10
	Toronto	P	5	5	[d]		14	10
	Windsor	P	7	8	[d]		15	17
Quebec:	Montreal	P	8	11	[d]		23	26
	Quebec	P						
Saskatchewan:	Regina	P	6	7	[d]		15	12
	Saskatoon	P	9	8	[d]		9	11
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	2	2	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	8	5	0	0	30	94
Venezuela:	Caracas	P	2	2	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	0	0 (4)	0	10 (4)	9
Puerto Rico:	San Juan[c]	P	4	3	0 (4)	0	4 (4)	7
PMN Network average [f]			7	7	0	0	6	8

[a] P, pasteurized milk. R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine–131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium–137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium–90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the PHS Pasteurized Milk Network stations denoted by footnote[c].

NA, no analysis.
NS, no sample collected.

the respective practical reporting levels. Averages for those stations at which strontium–89 was detected were Del Norte, Calif., 19 pCi/liter; and Humboldt, Calif., 6 pCi/liter.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine–131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 23 pCi/liter in the United States for the month of April 1970, and the highest 12-month average was 20 pCi/liter (Del Norte, Calif.) representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 46 pCi/liter in the United States for the month of April 1970, and the highest 12-month average was 79 pCi/liter (Southeast Fla.), representing 2.2 percent of the value presented in this report using the recommendation given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 results for individual samples were all below the practical reporting level.

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Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and presented routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	October–December 1968 and January–March 1969	May 1970
Connecticut Diet Study	July–December 1968 and January–June 1969	February 1970
Strontium–90 in Tri-City Diets, *HASL*	June–December 1969	June 1970

1. Radionuclides in Institutional Diet Samples October–December 1969 and Annual Summary 1969

Bureau of Radiological Health and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Office of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in fifty municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of December 1969, 20 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, are being sampled. The station at Chicago, Ill., was discontinued because of difficulty in locating a new institution. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1–2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other

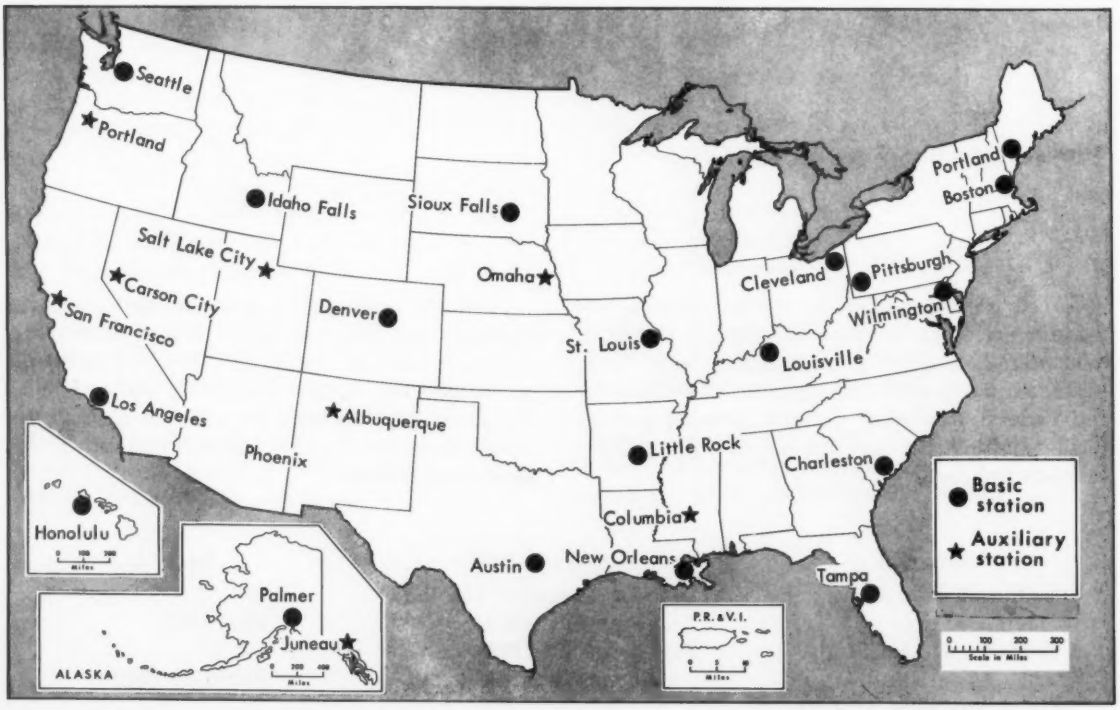

Figure 1. Institutional diet sampling locations as of December 1969

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), October–December 1969[a]

Location of institution		Month (1969)	Total weight (kg/day)	Calcium[b]		Potassium		Strontium-89[b]		Strontium-90[b]		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Palmer	Oct	1.23	0.6	0.8	1.4	1.7	0	0	7	9	0	0
		Nov	1.65			1.0	1.7					0	0
		Dec	1.10			1.7	1.8					16	18
Ariz:	Phoenix	Oct	2.04	.6	1.1	1.0	2.0	0	0	3	6	0	0
		Nov	1.81			1.7	3.0					0	0
		Dec	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ark:	Little Rock	Oct	1.14	.7	1.0	1.5	1.7	NA	NA	7	10	0	0
		Nov	1.23			1.5	1.8					11	14
		Dec	1.88			1.5	2.9					16	30
Calif:	Los Angeles	Oct[c]	1.79	.4	.6	1.0	1.8	0	0	2	3	0	0
		Nov[c]	1.60			1.0	1.6					0	0
		Dec[c]	1.38			1.2	1.6					0	0
Del:	Wilmington	Oct	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		Nov	2.08	.7	1.5	1.5	3.1	NA	NA	7	16	0	0
		Dec	2.36			1.4	3.3					12	28
Fla:	Tampa	Oct	1.33	.7	1.0	1.3	1.7	NA	NA	7	10	23	31
		Nov	1.31			1.5	2.0					28	37
		Dec[c]	1.54			1.6	2.5					20	31
Hawaii:	Honolulu	Oct[c]	2.11	.3	.6	1.3	2.8	0	0	0	0	0	0
		Nov	2.13			1.4	2.9					0	0
		Dec	2.23			1.3	2.9					0	0
Idaho:	Idaho Falls	Oct[c]	2.06	.9	1.7	1.4	2.9	NA	NA	7	14	0	0
		Nov[c]	1.95			1.7	3.3					13	25
		Dec[c]	1.86			1.6	3.0					14	26
Ky:	Louisville	Oct	2.57	.7	1.7	1.5	3.9	NA	NA	8	19	14	36
		Nov	2.47			1.5	3.7					0	0
		Dec	2.48			1.6	4.0					12	30
La:	New Orleans	Oct[c]	2.01	.6	1.2	1.5	3.0	0	0	7	14	0	0
		Nov	1.92			1.6	3.0					14	27
		Dec	2.15			1.5	3.2					0	0
Maine:	Portland	Oct	1.55	.8	1.3	1.5	2.3	NA	NA	9	4	13	19
		Nov	1.54			1.5	2.3					16	25
		Dec	1.45			1.7	2.5					26	38
Mass:	Boston	Oct	2.05	.6	1.4	1.8	3.7	0	0	5	11	12	25
		Nov	2.22			1.7	3.8					15	33
		Dec	1.96			1.5	2.9					14	27
Mo:	St. Louis	Oct	2.59	.9	2.2	1.9	4.9	NA	NA	7	17	0	0
		Nov	2.07			1.9	3.9					0	0
		Dec[c]	2.67			1.8	4.8					11	29
Ohio:	Cleveland	Oct	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		Nov	1.38	.7	1.0	1.5	2.1	NA	NA	6	9	0	0
		Dec	1.61			1.6	2.6					11	18
Pa:	Pittsburgh	Oct	2.35	.5	1.1	1.4	3.3	NA	NA	5	11	0	0
		Nov	2.23			1.4	3.1					11	25
		Dec	2.23			1.4	3.1					12	27
S.C:	Charleston	Oct	1.88	.8	1.6	1.4	2.6	0	0	7	14	14	26
		Nov	2.29			1.6	3.7					20	46
		Dec	1.81			1.5	2.8					15	27
S. Dak:	Sioux Falls	Oct	1.61	.8	1.2	1.4	2.3	NA	NA	8	12	0	0
		Nov	1.46			1.5	2.2					11	16
		Dec	1.27			1.5	1.9					12	15
Tex:	Austin	Oct[c]	1.64	.8	1.6	1.5	2.5	NA	NA	4	9	0	0
		Nov[c]	2.41			1.5	3.7					0	0
		Dec[c]	2.13			1.5	3.2					0	0
Wash:	Seattle	Oct[c]	1.96	.5	1.0	1.6	3.1	0	0	6	12	0	0
		Nov[c]	2.04			1.4	2.9					0	0
		Dec[c]	1.92			1.5	2.9					0	0
Institutional average		Oct	1.85	0.7	1.2	1.5	2.7	0	0	6	11	7	12
		Nov	1.85			1.5	2.8					8	14
		Dec	1.88			1.5	2.8					12	21

[a] Iodine-131 and barium-140 were not detected at these stations during this period.
[b] Composite analysis of quarterly samples for each station.
[c] Since food samples were collected from two or more children who were not between the ages of 9 to 12, the gamma analyses for this month were not used in the institutional average. All chemistry data were included in the institutional average since this analysis was a composite of three or less individual samples.
NA, no analysis.
NS, no sample.

in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1969, for children 9 to 12 years of age. The stable elements, calcium and

Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of individuals (auxiliary stations), October–December 1969[a]

Location of institution	Month (1969)	Total weight (kg/day)	Calcium[b]		Potassium		Strontium-89[b]		Strontium-90[b]		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Oct	1.05	0.4	0.5	1.4	1.4	0	0	4	4	13	14
	Nov	1.26			1.8	2.3					0	0
	Dec	1.35			1.8	2.4					35	47
Calif: San Francisco	Oct	2.18	.4	.8	1.4	3.1	0	0	2	5	0	0
	Nov	2.17			1.5	3.1					0	0
	Dec	2.28			1.4	3.2					0	0
Miss: Columbia	Oct	2.62	.9	1.9	1.4	3.6	NA	NA	6	14	0	0
	Nov	1.94			1.6	3.0					0	0
	Dec	2.06			1.5	3.0					12	15
Nebr: Omaha	Oct	2.31	.9	2.0	1.7	3.9	NA	NA	5	11	0	0
	Nov	2.36			1.6	3.8					0	0
	Dec	2.08			1.7	3.5					11	23
Nev: Carson City	Oct	1.71	.6	.8	1.4	2.4	0	0	4	5	0	0
	Nov	1.28			1.5	1.9					0	0
	Dec	1.03			1.9	1.9					0	0
N. Mex: Albuquerque	Oct	2.00	.9	2.0	1.7	3.4	NA	NA	4	8	0	0
	Nov	2.36			1.5	3.6					16	38
	Dec	2.44			1.3	3.1					0	0
Oreg: Portland	Oct	1.78	.6	1.1	2.3	4.1	0	0	7	14	13	23
	Nov	2.21			2.0	4.4					12	27
	Dec	1.85			1.6	3.0					0	0
Utah: Salt Lake City	Oct	2.74	.5	1.4	1.1	2.9	0	0	2	6	0	0
	Nov	2.80			1.0	2.8					0	0
	Dec	2.68			1.3	3.4					0	0
Institutional average	Oct	2.05	0.6	1.3	1.5	3.1	0	0	4	8	3	5
	Nov	2.05			1.6	3.1					4	8
	Dec	1.97			1.6	2.9					7	12

[a] Iodine-131 and barium-140 were not detected at these stations during this period.
[b] Composite analysis of quarterly samples for each station.
NA, no analysis.

potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.86 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium–90 dietary intake during this period averaged 6 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium–137 intakes averaged 9 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level are reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium–89	5 pCi/kg
Strontium–90	2 pCi/kg
Iodine–131	10 pCi/kg
Barium–140	10 pCi/kg
Cesium–137	10 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9–12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Annual averages

Annual average radionuclide concentrations and intakes are presented in tables 3 and 4 for the basic and auxiliary stations. During 1969, the annual average intake for the basic stations was 1.87 kg/day as compared to 1.98 kg/day in the auxiliary stations. The levels of radionuclide concentrations in both the basic and auxiliary stations were similar.

Table 3. 1969 annual average concentration and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age)[a]

Location of institution		Total weight (kg/day)	Calcium[b]		Potassium		Strontium-90[b]		Cesium-137		Radium-226[c]	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Palmer	1.47	0.6	0.8	1.3	1.8	6	8	6	7	0.4	0.6
Ariz:	Phoenix	1.83	.6	1.1	1.5	2.7	2	4	0	0	.4	.7
Ark:	Little Rock	1.40	.5	.8	1.4	2.0	8	11	9	12	.6	.8
Calif:	Los Angeles[d]	1.61	.4	.7	1.1	1.7	2	3	0	0	.4	.8
Colo:	Denver	2.22	.8	1.7	1.4	3.0	6	13	0	0	.7	1.6
Del:	Wilmington	2.17	.6	1.5	1.6	3.6	7	15	6	14	.6	1.3
Fla:	Tampa	1.33	.6	.8	1.4	2.0	7	9	28	37	.8	1.0
Hawaii:	Honolulu	2.54	.4	.9	1.4	3.6	3	8	9	25	.4	1.2
Idaho:	Idaho Falls[d]	2.01	1.0	2.1	1.6	3.3	8	16	10	20	.6	1.2
Ky:	Louisville	2.29	.7	1.6	1.6	3.7	9	19	6	14	.7	1.5
La:	New Orleans	2.00	.5	1.1	1.6	3.2	9	18	4	5	.4	.8
Maine:	Portland	1.69	.8	1.4	1.7	2.9	11	18	24	41	.6	1.1
Mass:	Boston	2.12	.6	1.3	1.8	3.8	8	16	18	38	.6	1.2
Mo:	St. Louis[d]	2.43	1.0	2.4	1.8	4.4	8	20	5	8	.0	2.6
Ohio:	Cleveland	1.60	.7	1.1	1.8	2.8	7	11	4	7	.6	1.0
Pa:	Pittsburgh	2.27	.5	1.2	1.4	3.2	7	16	5	11	.7	1.5
S.C:	Charleston	1.66	.7	1.1	1.4	2.4	9	14	16	25	.6	1.0
S. Dak:	Sioux Falls	1.47	.7	1.1	1.4	2.0	7	10	4	5	.8	1.2
Tex:	Austin[d]	1.93	.8	1.6	1.5	3.0	4	8	0	0	.4	.8
Wash:	Seattle[d]	1.92	.6	1.1	1.5	2.9	6	11	5	12	.5	1.0
Institutional average		1.87	0.6	1.2	1.5	3.0	7	13	9	16	0.6	1.1

[a] Strontium-89, iodine-131, and barium-140 were not detected at most stations during the year 1969. The exceptions are as follows:
January: 6 pCi/kg of strontium-89 was reported in Phoenix, Ariz.
February: 12 pCi/kg of iodine-131 was reported in Pittsburgh, Pa.
July: 6 pCi/kg of strontium-89 was reported in Boston, Mass.
[b] Composite analysis of quarterly samples for last 6 months of year.
[c] Radium analyses were only conducted for first 6 months of year.
[d] Since food samples were collected from two or more children who were not between the ages of 9 to 12, the gamma analyses were not used in the institutional average. All chemistry data were included in the institutional average since this analysis for the last 6 months of the year was a composite of three or less individual samples.

Table 4. 1969 annual average concentration and intake of stable elements and radionuclides in institutional total diets of individuals (auxiliary stations)[a]

Location of institution		Total weight (kg/day)	Calcium[b]		Potassium		Strontium-90[b]		Cesium-137		Radium-226[c]	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Juneau	1.19	0.5	0.7	1.5	1.8	8	9	12	14	0.4	0.6
Calif:	San Francisco	2.15	.5	1.1	1.5	3.2	3	7	2	5	.4	.9
Miss:	Columbia	2.16	.9	2.0	1.5	3.3	8	18	15	32	.6	1.2
Nebr:	Omaha	2.32	.9	1.9	1.7	4.0	6	13	4	9	.8	1.8
Nev:	Carson City	1.48	.7	1.0	1.4	2.0	3	5	3	5	.5	.8
N. Mex:	Albuquerque	2.38	.8	2.0	1.5	3.6	3	7	2	5	.4	1.0
Oreg:	Portland	1.84	.6	1.0	1.9	3.4	5	10	3	6	.5	.9
Utah:	Salt Lake City	2.30	.5	1.2	1.2	2.7	2	6	1	2	.4	.8
Institutional average		1.98	0.7	1.4	1.5	3.0	5	9	5	10	0.5	1.0

[a] Strontium-89, iodine-131 and barium-140 were not detected at most stations during the year 1969.
The exceptions are as follows:
January: 8 pCi/kg of strontium-89 was reported in Portland, Oreg.
July: 11 pCi/kg of strontium-89 was reported in Juneau, Alaska.
November: 12 pCi/kg of barium-140 was reported in Albuquerque, N. Mex.
[b] Composite analysis of quarterly samples for each station for the last 6 months of the year.
[c] Radium analyses were only conducted for first 6 months of year.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1969 and Annual Summary 1968	October 1969
April–June 1969	January 1970
July–September 1969	June 1970

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(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
Minnesota	January–June 1969	January 1970
New York	January–June 1969	June 1970
North Carolina	January–December 1967	May 1969
Radiostrontium in tap Water, *HASL*	January–December 1969	July 1970
Tritium Network	July–December 1969	July 1970
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in California Waters[1] July-December 1968

Bureau of Radiological Health
State of California Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Specific radionuclides are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

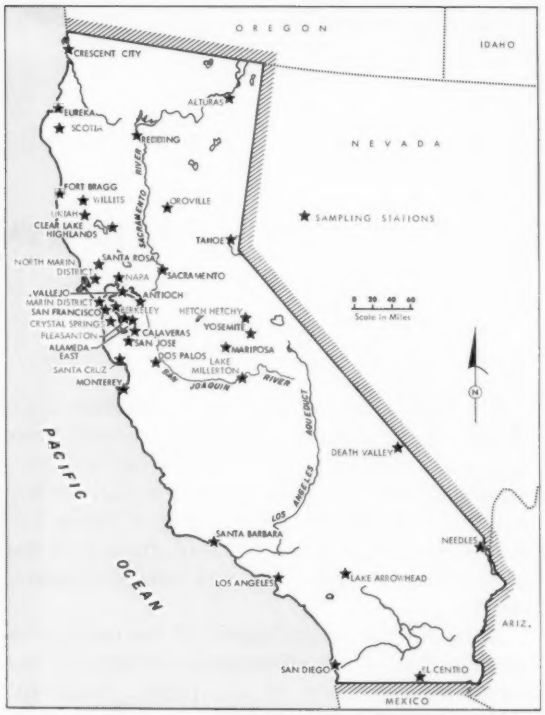

Figure 1. California surface water sampling stations

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California from July through December 1968. Following treatment, these waters are used for industrial and domestic

[1] Data from January and April 1969 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

Table 1. Gross beta radioactivity in California domestic waters, July–December 1968

Sampling station	Quality	Concentration (pCi/liter)					
		July	August	September	October	November	December
Alturas	Well	±13	±15	±8	39	NS	±11
Antioch	Treated	±4	±1	±2	±4	NS	±8
Berkeley	Treated	±3	34	±3	±6	±5	±9
Clearlake Highlands	Treated	±2	±15	±10	±8	±10	±12
Crescent City	Well	NS	±17	±6	±10	±8	NS
Death Valley	Treated	±31	±15	±21	±21	±17	±5
Dos Palos	Treated	ND	±8	±3	±10	NS	±14
El Centro	Treated	ND	±26	±10	NS	NS	NS
Eureka	Raw	31	±10	±9	0	±10	0
	Treated	±2	±3	ND	±7	±2	0
Fort Bragg	Treated	NS	NS	ND	ND	±4	ND
Lake Arrowhead	Treated	NS	NS	ND	±10	±13	ND
Lake Millerton	Raw	ND	29	ND	±7	0	±8
Los Angeles	Raw	NS	±14	NS	NS	NS	0
Marin Municipal Water District	Treated	±2	±9	ND	±9	±2	NS
Mariposa	Treated	ND	NS	NS	NS	NS	NS
Metropolitan Water District of Southern California:							
Weymouth Plant	Treated	52	65	±27	55	NS	93
Monterey	Treated	±11	ND	±1	NS	±8	NS
Napa	Treated	27	±13	±6	±7	±13	NS
Needles	Well	±26	±9	±1	NS	NS	NS
North Marin Water District	Treated	±10	18	±15	±7	±2	NS
	Raw	±4	±13	±19	±3	0	NS
	Sludge[b]	±23	±36	±72	±19	±25	NS
Oroville:							
Wyandotte Irrigation District	Treated	±4	ND	ND	±3	±13	0
Pleasanton	Well	±10	ND	ND	±8	±4	±8
Redding	Treated	NS	NS	NS	NS	NS	±5
Sacramento:							
American River	Treated	±8	±4	NS	±9	NS	±3
Sacramento	Treated	±9	ND	NS	±16	NS	0
San Diego	Raw	ND	ND	8	±13	±8	±24
	Treated	±18	NS	±20	±3	0	±3
San Francisco:							
Water Department	Raw	±1	18	±7	0	±3	±2
Alameda, East	Raw	±3	ND	±11	0	NS	0
Brightside Weir	Raw	±1	NS	±6	±2	NS	±5
Calaveras Reservoir	Raw	ND	±13	±8	0	±10	0
Crystal Springs	Raw	±2	NS	NS	NS	NS	±9
Hetch Hetchy	Raw	±7	NS	NS	NS	NS	NS
San Jose	Raw	ND	±8	ND	0	±8	NS
Santa Barbara	Treated	±14	±2	±2	±14	±12	±6
Santa Cruz	Raw	ND	ND	±7	±7	NS	±4
Santa Rosa	Raw	31	ND	ND	0	±3	0
Scotia	Raw	±17	±5	±20	±3	±5	0
Tahoe City	Raw	NS	NS	ND	NS	NS	NS
Ukiah	Well	ND	NS	ND	±1	NS	NS
Vallejo:							
Fleming Hill	Raw	±4	ND	±3	±5	±6	±17
	Treated	ND	±8	±9	±9	±8	0
Willits	Treated	±7	ND	61	0	0	NS
Yosemite	Treated	±7	±13	±5	±6	0	±16
Maximum		52	65	61	55	17	93
Minimum		1	1	1	0	0	0

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.
[b] Sludge reported in pCi/g (dry weight).
NS, no sample collected.
ND, no detectable activity.

purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. Radioactivity or very slight, alpha radioactivity analyses are not presented. Radioactivity in surface water remains low. No increase has been observed in drinking water because of the testing of nuclear devices during the past several years.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	December 1969

REFERENCE

(1) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59–6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas, HASL	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	July–December 1969	June 1970
Tritium in Precipitation	July–December 1969	July 1970

1. Radiation Alert Network April 1970

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation as measured by the field estimate technique during April 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, April 1970

Station location		Air surveillance				Last profile in RHD&R	Precipitation				
		Number of samples	Gross beta radioactivity (pCi/m³)				Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	22	6	0	2	Dec 69	3	61	3	61	29
Alaska:	Adak	[b]				Dec 69	[c]				
	Anchorage	[b]				June 70	[c]				
	Attu Island	20	0	0	0	Jan 70	[c]				
	Fairbanks	15	1	0	0	July 70	1	2	1	2	1
	Juneau	[b]				Oct 69	[c]				
	Kodiak	7	0	0	0	Nov 69	[c]				
	Nome	6	1	0	1	Mar 70	[c]				
	Point Barrow	28	1	0	0	Feb 70	[c]				
	St. Paul Island	[b]				Apr 70	[c]				
Ariz:	Phoenix	14	12	1	4	Oct 69	[c]				
Ark:	Little Rock	10	2	0	1	June 70	[c]				
Calif:	Berkeley	22	1	0	0	Nov 69	[c]				
	Los Angeles	21	3	0	1	Mar 70	[c]				
C.Z:	Ancon	17	0	0	0	Nov 69	[c]				
Colo:	Denver	22	6	1	3	Nov 69	4	31	[d]		
Conn:	Hartford	22	1	0	1	July 70	7	81	7	81	3
Del:	Dover	21	1	0	0	May 70	[c]				
D.C:	Washington	20	1	0	0	Feb 70	[c]				
Fla:	Jacksonville	22	2	0	1	June 70	4	51	4	51	13
	Miami	16	1	0	0	July 70	1	7	1	7	0
Ga:	Atlanta	21	1	1	1	Apr 70	1	74	1	74	37
Guam:	Agana	[b]				May 70	[c]				
Hawaii:	Honolulu	25	1	0	1	Jan 70	7	51	[d]		
Idaho:	Boise	22	3	1	2	Jan 70	6	28	6	28	4
Ill:	Springfield	20	4	0	2	Feb 70	[c]				
Ind:	Indianapolis	[b]				Apr 70	[c]				
Iowa:	Iowa City	20	6	0	2	Nov 69	6	76	6	76	3
Kans:	Topeka	21	5	0	2	June 70	4	69	4	69	3
Ky:	Frankfort	[b]				Feb 70	[c]				
La:	New Orleans	14	1	0	1	Feb 70	7	23	[d]		
Maine:	Augusta	22	2	0	1	Mar 70	3	118	3	118	0
Md:	Baltimore	22	1	0	1	July 70	9	76	9	76	21
	Rockville	15	2	0	1	Jan 70	[c]				
Mass:	Lawrence	21	1	0	1	May 70	5	88	5	88	12
	Winchester	22	2	0	1	Dec 69	7	95	7	95	0
Mich:	Lansing	20	1	0	0	Jan 70	7	36	7	36	6
Minn:	Minneapolis	22	2	0	1	May 70	5	106	5	106	24
Miss:	Jackson	15	1	0	1	Mar 70	2	65	2	65	9
Mo:	Jefferson City	21	3	0	1	Apr 70	9	143	9	143	0
Mont:	Helena	18	2	0	1	Dec 69	1	9	1	9	15
Nebr:	Lincoln	15	7	1	3	Apr 70	4	58	4	58	12
Nev:	Las Vegas	13	2	1	1	July 70	[c]				
N.H:	Concord	[b]				Feb 70	[c]				
N.J:	Trenton	19	3	0	1	Mar 70	7	113	7	113	9
N. Mex:	Santa Fe	18	3	0	1	Dec 69	3	9	3	9	0
N.Y:	Albany	[b]				Apr 70	1	9	1	9	6
	Buffalo	21	2	0	1	Nov 69	[c]				
	New York City	15	1	0	0	Dec 69	[c]				
N.C:	Gastonia	18	9	1	4	Nov 69	3	30	[d]		
N. Dak:	Bismarck	22	2	0	1	Feb 70	9	166	9	166	10
Ohio:	Cincinnati	[b]				May 70	[c]				
	Columbus	4	2	1	1	Mar 70	[c]				
	Painesville	[b]				July 70	4	40	3	21	9
Okla:	Oklahoma City	[b]				Jan 70	[c]				
	Ponca City	22	5	0	1	July 70	8	96	8	96	1
Oreg:	Portland	22	4	0	1	Apr 70	13	97	13	97	3
Pa:	Harrisburg	15	1	0	0	Apr 70	3	54	3	54	16
P.R:	San Juan	[b]				Mar 70	[c]				
R.I:	Providence	19	2	0	1	Jan 70	3	80	3	80	9
S.C:	Columbia	19	3	0	1	Dec 69	3	73	3	73	5
S. Dak:	Pierre	13	6	1	3	Oct 69	[c]				
Tenn:	Nashville	22	2	0	1	Jan 70	8	148	8	148	12
Tex:	Austin	16	4	0	2	May 70	[c]				
	El Paso	[b]				Feb 70	[c]				
Utah:	Salt Lake City	30	4	0	2	Mar 70	9	63	9	63	7
Vt:	Barre	19	3	0	1	June 70	6	76	6	76	12
Va:	Richmond	21	1	0	0	June 70	6	45	6	45	10
Wash:	Seattle	25	0	0	0	June 70	10	53	[d]		
	Spokane	22	2	0	1	May 70	[c]				
W. Va:	Charleston	22	3	0	1	Dec 69	11	78	11	78	16
Wisc:	Madison	22	4	0	1	June 70	7	73	7	73	8
Wyo:	Cheyenne	22	3	0	1	July 70	1	1	1	1	0
Network summary		1,122	12	0	1		5	65	5	68	9

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

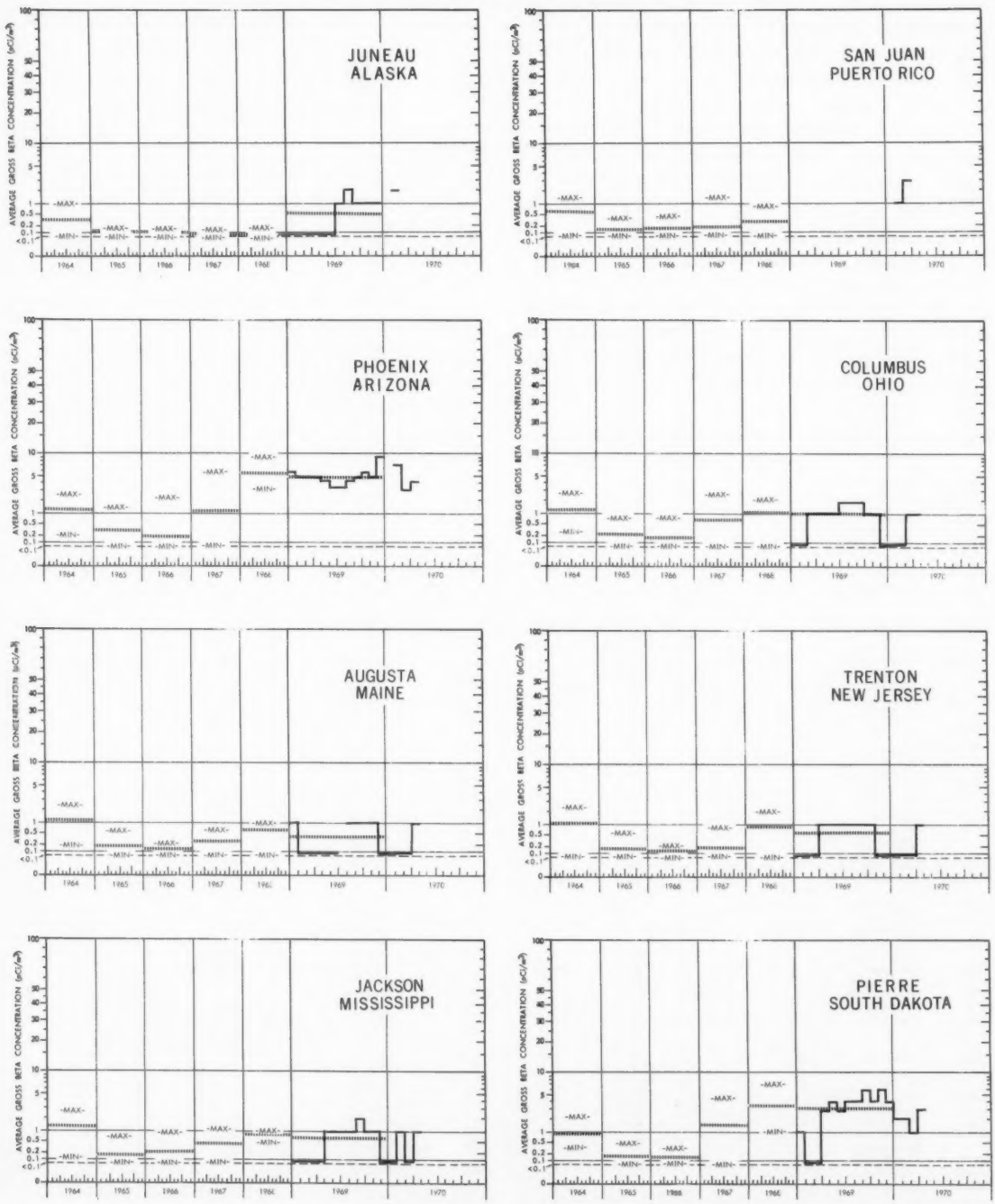

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–April 1970

2. Canadian Air and Precipitation Monitoring Program[1], April 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for April 1970 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.6	0.1	0.2	16	0.6
Coral Harbour	27	.3	.1	.2	NS	NS
Edmonton	30	.4	.1	.2	260	1.1
Ft. Churchill	30	.2	.1	.1	123	.6
Fredericton	30	.5	.1	.2	54	4.9
Goose Bay	28	.2	.0	.1	31	1.9
Halifax	30	.5	.0	.2	86	5.2
Inuvik	28	.2	.1	.1	43	.4
Montreal	30	.5	.0	.2	106	6.7
Moosonee	30	.3	.0	.1	53	1.7
Ottawa	29	.4	.0	.2	68	4.0
Quebec	30	.3	.0	.2	62	4.6
Regina	30	.3	.0	.2	32	1.4
Resolute	30	.2	.1	.2	13	.1
St. John's, Nfld.	28	.4	.0	.1	19	2.8
Saskatoon	28	.3	.1	.2	NS	NS
Sault Ste. Marie	29	.5	.0	.2	144	5.2
Thunder Bay	29	.4	.1	.2	98	10.3
Toronto	29	.6	.1	.3	96	7.9
Vancouver	30	.3	.0	.1	58	6.6
Whitehorse	30	.2	.0	.1	38	.5
Windsor	29	.5	.1	.2	107	8.6
Winnipeg	30	.4	.1	.2	66	4.3
Yellowknife	27	.2	.1	.2	202	1.1
Network summary	701	0.6	0.0	0.2	81	3.7

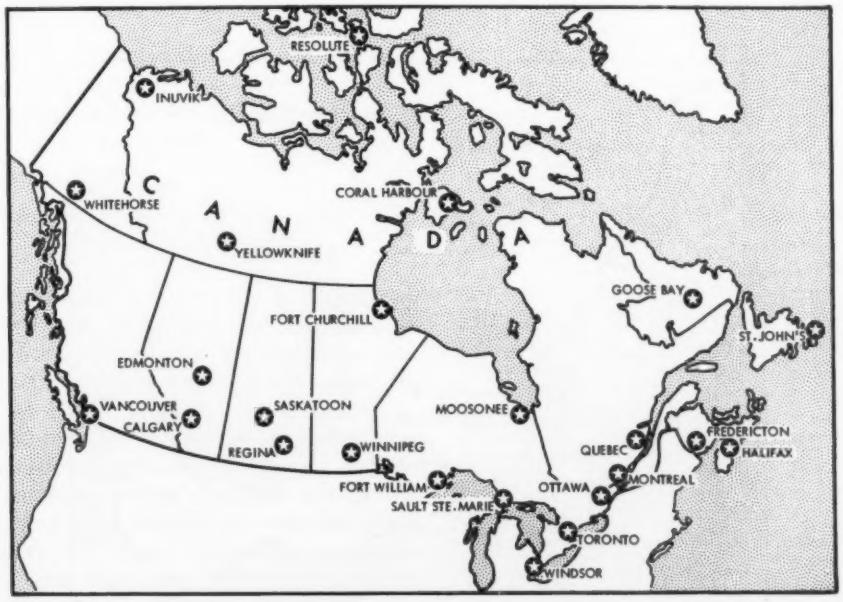

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program December 1969

National Commission of Nuclear Energy
Mexico, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during December 1969 is presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, December 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	7	0.2	0.1	0.1
Ciudad Juarez	6	.3	.1	.2
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	12	.3	.1	.2
Matamoros	NS			
Mazatlán	NS			
Mérida	11	.3	.1	.2
México, D.F.	7	.1	<.1	.1
Nuevo Laredo	5	.11	.1	.1
San Luis Potosí	NS			
Tampico	NS			
Torreón	5	.4	.1	.2
Veracruz	NS			

NS, no sample, station temporarily shutdown.

Figure 5. Pan American Air Sampling Program stations

4. Pan American Air Sampling Program April 1970

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The April 1970 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, April 1970

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina: Buenos Aires	NS			
Bolivia: La Paz	NS			
Chile: Santiago	20	0.19	0.02	0.06
Colombia: Bogota	28	.13	.00	.06
Ecuador: Cuenca	NS			
Guayaquil	NS			
Quito	NS			
Guyana: Georgetown	13	.37	.11	.24
Jamaica: Kingston	NS			
Peru: Lima	26	.07	.02	.04
Venezuela: Caracas	20	.50	.09	.26
West Indies: Trinidad	12	.28	.12	.19
Pan American summary	119	0.50	0.00	0.12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Reported values of less than 0.005 pCi/m³ are considered as 0.00 pCi/m³ in averaging.
NS, no sample.

5. Plutonium in Airborne Particulates January–March 1969

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate samples from selected RAN stations for plutonium. The airborne particulate analyses were initiated in November 1965, and the results through December 1968 have been previously reported (*7–18*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. The laboratory reduced this analysis on filters to quarterly composites as of the August 1968 sample. They also discontinued analysis of precipitation for plutonium due to consistently low levels of plutonium in the environment after September 30, 1968.

The results for January through March 1969 are presented in table 5. ND (nondetectable) has been used to indicate samples containing plutonium–238 or plutonium–239 activities less than or equal to the appropriate minimum detectable activities (.020 pCi and .015 pCi per sample for plutonium–238 and plutonium–239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples.

Table 5. Plutonium in airborne particulates, January–March 1969

	Anchorage	Phoenix	Denver	Honolulu	New Orleans	Rockville	Buffalo	Gastonia	Pierre	Austin	Seattle
Plutonium-238 (fCi/m³) January–March	.017	.018	.019	.008	.014	.011	.008	.013	.008	.013	.007
Plutonium-239 (fCi/m³) January–March	.065	.077	.071	.033	.058	.040	.036	.058	.033	.047	.032
$^{239}Pu/^{238}Pu$ January–March	3.82	4.28	3.74	4.12	4.14	3.64	4.50	4.46	4.12	3.62	4.57

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(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

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(*8*) DIVISION OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–June 1966. Radiol Health Data Rep 7:666–667 (November 1966).

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(17) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July–September 1968. Radiol Health Data Rep 11:92–93 (February 1970).
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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual.[1]"

Summaries of the environmental radioactivity data follow for Atomics International, Neutron Devices Department, and Feed Materials Production Center.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Atomics International.[2] July–December 1969

North American Rockwell Corporation
Canoga Park, Calif.

Atomics International, a division of North American Rockwell Corporation, has engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is located in the Simi Hills of Ventura County, approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International requires adequate containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a measure of the effectiveness of the company's radiological safety procedures and of engineering safeguards incorporated into facility designs.

The onsite environs of Atomic International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. The offsite environs are sampled monthly, except for soil and vegetation which are sampled quarterly. In addition, continuous environmental air monitoring at the sites provides information

[2] Summarized from "Environmental Monitoring, Semiannual Report, July 1, 1969 to December 31, 1969" Atomics International, Division of North American Rockwell Corporation.

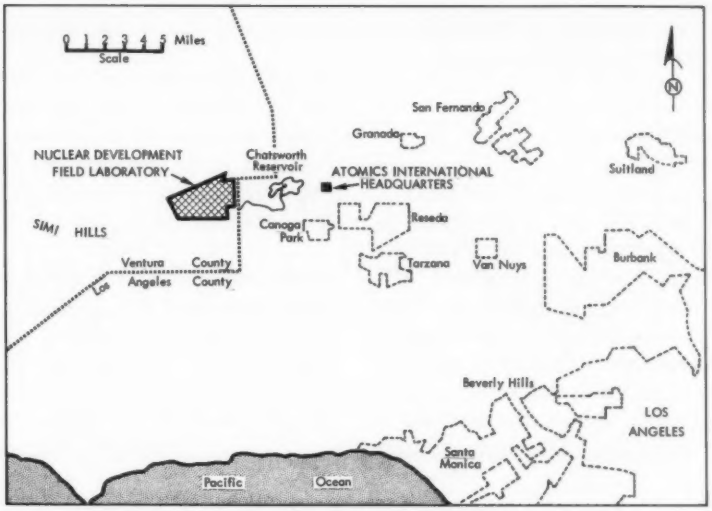

Figure 1. Atomics International facilities and vicinity

concerning long-lived airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 1 for July–December 1969.

Table 1. Beta-gamma radioactivity of airborne particulates, Atomics, July–December 1969

Location	Number of samples	Average concentration[a] (pCi/m³)
Headquarters	325	0.30
NDFL	1,150	.29

[a] Minimum detectable level—0.04 pCi/m³.

When abnormally high airborne radioactivities are observed, the radioactivity decay data are plotted to determine the presence of short-lived isotopes other than naturally occurring radon, thoron, and daughters. If fallout is suspected, the decay characteristics are observed. If the radioactivity decays as a function of $t^{-1.2}$, the data curve is extrapolated in order to determine the date of origin. This data is compared with the dates of publicized nuclear detonations to determine if the abnormal airborne radioactivity was caused by such detonations.

A graph of averaged long-lived airborne radioactivity concentrations detected at the Headquarters and NDFL facilities during the second half of 1969 is presented in figure 2. The graph shows the incidence of several sustained periods of increased airborne radioactivity during the year, with a generally increasing trend through the spring months and diminishing through the fall. No significant transient peaks were detected during 1969.

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied

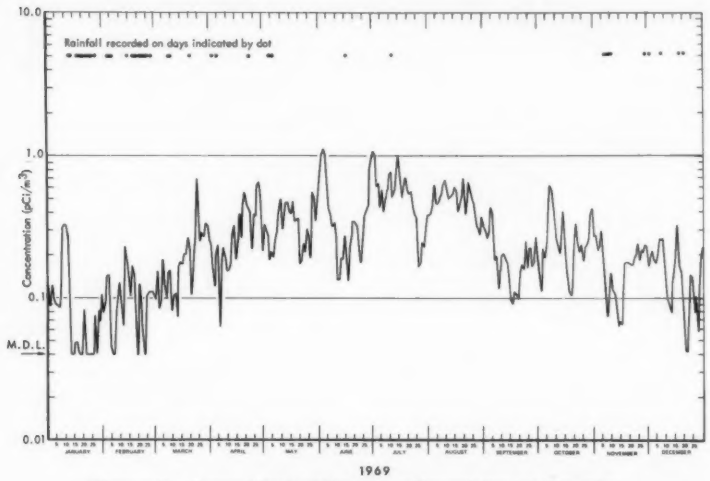

Figure 2. Long-lived airborne radioactivity at Atomics International, 1969

by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 2.

Table 2. Process water radioactivity, NDFL site July–December 1969

Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.06
Beta-gamma	12	5.5

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The lake was drained in July 1969 for construction, thereby precluding sampling for most of the last half of 1969. The average radioactivity for both surface and supply water samples is presented in table 3.

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66–49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon approximately 2.5 miles downstream from the south NDFL boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 3. Chatsworth Reservoir water radioactivity Atomics, July–December 1969

Sample	Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	2	0.28
	Beta-gamma	2	8.0
Supply inlet	Alpha	6	.11
	Beta-gamma	6	4.7

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek[a], July–December 1969

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir station 6 water[a] (pCi/liter)	6	0.03	6.9
Reservoir station 12 water[a] (pCi/liter)	6	.05	6.7
Bell Creek mud (pCi/g)	6	.28	25
Bell Creek vegetation (pCi/g ash)	6	.15	148
Bell Creek water (pCi/liter)	6	.03	4.0

[a] Location not shown on figure 1.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 25 locations. Eleven sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 14 stations, located within a 10-mile radius of the sites, are referred to as "off-site" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 5.

Table 5. Radioactivity in the soil, Atomics July–December 1969

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.41
	Beta-gamma	72	27
Offsite	Alpha	24	.38
	Beta-gamma	24	25

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 6.

Table 6. Radioactivity in vegetation, Atomics July–December 1969

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.34
	Beta-gamma	72	171
Offsite	Alpha	24	.34
	Beta-gamma	24	146

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	July 1969
January–June 1969	March 1970

2. Feed Materials Production Center.[3] July–December 1969

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 3. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

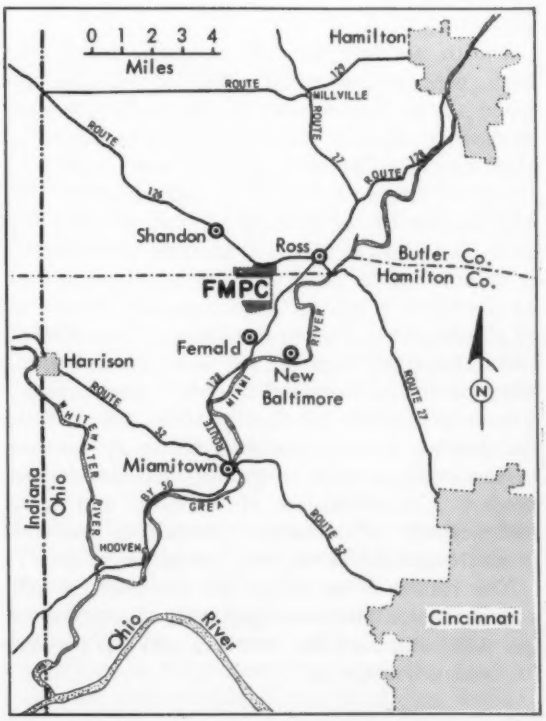

Figure 3. Areas map of Feed Materials Production Center

[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1969, Summary Report for 1969 (NLCO–1055).

During the past 2 years the project has also processed thorium to produce purified oxide and metal. The process of these products is essentially the same as used in producing uranium.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. An environmental monitoring program has been established to determine the concentrations of plant materials in the water and air outside the project.

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 4. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 80 percent of all samples are taken downwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the project. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 7.

The results of sampling indicate that the offsite concentrations averaged only 5 percent of the AEC standard for uranium and 0.2 percent for total radioactivity.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for additional treatment

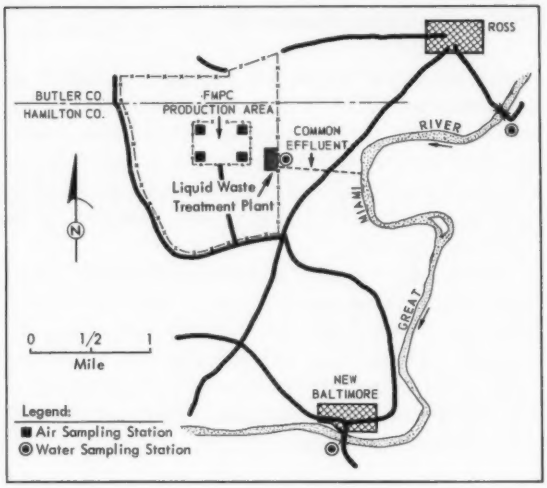

Figure 4. Air and water sampling stations, FMPC

and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then combined with three other types of project waste water and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream; downstream, a continuous sample is taken for a 24-hour period and at least one sample is analyzed each week. Samples of the storm sewer overflow are collected in an automatic flow integrated sampler when overflow occurs. All samples are analyzed for uranium, total radioactivity and radium–228, a daughter of thorium–232. Since radium–228 has the lowest AEC standard, control of this radionuclide and of the total radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for July–December 1969 are summarized in table 8.

Table 7. Radioactivity levels of airborne particulates, FMPC, July–December 1969

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Total radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	22	0.2	<0.1	<0.1	0.6	<0.1	0.2
Northwest	24	.1	< .1	< .1	1.1	< .1	.2
Northeast	24	.4	< .1	.1	.8	< .1	.2
Southeast	23	.2	< .1	.1	.5	< .1	.2
All onsite samples	93			.1			.2
Offsite:							
0–2 miles from FMPC	32	.3	< .1	.1	1.5	< .1	.3
2–4 miles from FMPC	35	< .1	< .1	< .1	.5	< .1	.2
4–8 miles from FMPC	39	.1	< .1	< .1	.6	< .1	.2
8–12 miles from FMPC	10	< .1	< .1	< .1	.7	< .1	.3
All offsite samples	116			.1			.2

[a] AEC radiation protection standard—2 pCi/m³.
[b] AEC radiation protection standard—100 pCi/m³. Total radioactivity is the sum of the alpha and beta radioactivity.

Table 8. Radioactivity in the Great Miami River, FMPC, July-December 1969

Location	Number of samples	Total radioactivity[a] (pCi/liter)			Concentration (pCi/liter)						
					Uranium[b]			Radium-228[c]			
		Maximum	Minimum	Average	Maximum	Minimum	Average	Number of samples	Maximum	Minimum	Average
Sewer outfall[d]	184	260	<10	10	<10	<10	<10	22	2.35	0.05	0.70
Upstream from outfall	28	490	<10	<10	90	<10	15	7	2.27	.45	1.09
Downstream from outfall	28	100	<10	<10	10	<10	3	7	2.27	.45	1.27

[a] AEC standard—3,000 pCi/liter. Total radioactivity is the sum of the alpha and beta radioactivity.
[b] AEC standard—20,000 pCi/liter.
[c] AEC standard—30 pCi/liter.
[d] Concentrations in the river as calculated from sewer outfall sample results.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	August 1969
January–June 1969	March 1970

3. Neutron Devices Department.[4] July–December 1969

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 5) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained

[4] Summarized from "Environmental Monitoring, July 1 through December 1969" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

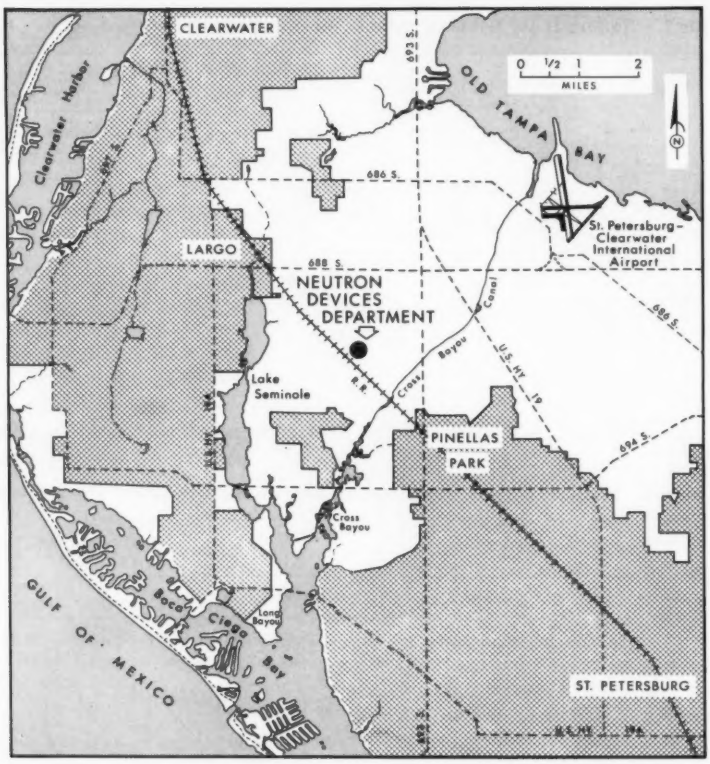

Figure 5. Location of the Neutron Devices Department

daily near the perimeter of the plant's property. During the sampling period seven of 104 samples analyzed showed detectable concentrations of tritium (>90 nCi/liter). The maximum concentration (1.27 μCi/liter, detected on August 28, 1969) represented 42 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system and the plant's water discharges indicate that the average tritium concentration in the combined sewer effluent for the second half of 1969 was less than 3.8 percent of the AEC standard for continuous nonoccupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90 nCi/liter) in the 115 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of 7 raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

Nine tritium gas and 11 tritium oxide in air samples were collected around the calculated locations of maximum ground level concentrations during intentional radioactivity releases. The maximum concentrations occurred onsite and represented approximately 33 percent and 17 percent of the AEC standards for tritium oxide and tritium gas, respectively.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	January 1970
January–June 1969	April 1970

Reported Nuclear Detonations, July 1970

(Includes seismic signals from foreign test areas)

The U.S. Atomic Commission announced that on July 20, 1970, the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals, which originated in the Semipalatinsk nuclear test area, were equivalent to those of an underground nuclear explosion in the low-intermediate yield range (20–200 kilotons TNT equivalent).

On July 23, 1970, the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals, which originated in the Semipalatinsk nuclear test area, were equivalent to those of an underground nuclear explosion in the low-intermediate yield range (20–200 kilotons TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A PRIORITY SYSTEM FOR THE INSPECTION OF X-RAY FACILITIES. *Bobby L. Dillard* and *Charles M. Hardin. Radiological Health Data and Reports, Vol. 11, August 1970*, pp. 367–372.

A method of establishing a priority system for performing radiation safety inspections of specific x-ray facilities by a State radiation control program is described. Data obtained from past inspections of radiographic fluoroscopic and dental x-ray facilities are evaluated, and a priority number is assigned to these facilities. Those facilities with the highest priority number will be surveyed first on the next round of inspections.

KEYWORDS: Fluoroscopy, inspection, Kentucky, radiography, safety, survey, system, x-ray facilities.

DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES, 1969. *J. J. Mangeno* and *M. E. Miles. Radiological Health Data and Reports, Vol. 11, August 1970*, pp. 373–378.

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships totaled 0.05 curies in 1969 for all harbors. This is comparable to the average of 0.2 curies discharged per year during the preceding 3 years for all harbors and is less than the average of 4 curies reported discharged per year during the preceding 5 years. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

KEYWORDS: Discharges, disposal, harbors, monitoring, nuclear-powered ships, radioactivity, U.S. Navy, wastes.

STANDBY MILK SURVEILLANCE NETWORK. *Thomas J. Sharpe* and *John L. Stein Radiological Health Data and Reports, Vol. 11, August 1970*, pp. 379–382.

The operation of the Standby Milk Surveillance Network of the Southwestern Radiological Health Laboratory is described. Portions of the network have been activated on several occasions. Fresh fission products have been defined in a number of samples collected from processing plants in the network, although in all cases the concentrations of the radionuclides present have been well below the recommendations of the Federal Radiation Council.

KEYWORDS: Milk, United States, iodine-131, surveillance network.

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